DISCOVERY

MARCH 1957

2/6

The "ORTHOTRON"

4 Mev Electron Linear Accelerator

A compact and economic source of high energy electrons for Industrial Irradiation Techniques such as:

Controlled cross linking and degradation of long chain polymers.

"Cold Sterilisation" of pharmaceutical products and thermally unstable antibiotics even after final packaging.

Write for Special Publication 7210/5 and details of irradiation service for research and pilot plant purposes.

METROPOLITAN-VICKERS
ELECTRICAL CO LTD · TRAFFORD PARK · MANCHESTER 17

Member of the A.E.I. group of companies

NR/506

Please cut out and file

ALWAYS "FIT"

AUTOSET

CASTORS

From Giants, as illustrated, down to 2" dia. wheel types. Four-ton twin pneumatic shown, but we do supply castors having load capacities up to

30 TONS EACH

Over **7000** types and sizes, including Normal, Equalising, Internal Expanding Braked, Anti-shimmy, Jacking, controlled Swivelling Wheel Brackets, and Ackerman steered coupled types. Large range of head fittings available. We also make Suspension Drawer Slides, Door Runners and Sheaves, Overhead Conveyor Rollers, Trolleys, Trucks, Engineers' Clamps, etc.

Engineers, Patentees and Sole Manufacturers

Ask for Brochure No. 389

AUTOSET (PRODUCTION) LTD 75–80 STOUR STREET, BIRMINGHAM 18

Established over 35 years

EDG 1143 (3 lines)

/TI7

DISCOVERY

EDITOR: Anthony R. Michaelis, Ph.D., B.Sc. EDITORIAL OFFICE: 244 High Holborn, W.C.1. CHAncery 6518
SUBSCRIPTION, DISTRIBUTION AND BUSINESS COMMUNICATIONS TO: Jarrold & Sons Ltd, Norwich. Norwich 25261
ADVERTISEMENT OFFICE: Aldridge Press Ltd, 27 Chancery Lane, W.C.2. HOLborn 8655

MARCH 1957 VOLUME XVIII NUMBER 3

CONTENTS

THE PROGRESS OF SCIENCE 89
- **Nobel Prizes for the Young?**
- **Hertzian Waves**
- **Giant Oil Tankers**
- **Experimental Brainwashing**
- **French Ramjet Reaches 1242 m.p.h.**
- **A New Naked-Eye Comet**
- **Neptune's Horses**
- **Flamsteed's Well**
- **Synthetic Detergents and Foaming in Sewage**

ELECTRONICS IN CIVIL AVIATION 100
J. C. Farmer, B.Sc., M.I.E.E.

POLARISED LIGHT AND ANIMALS 105
J. D. Carthy, M.A., Ph.D.

TWENTY-FIVE YEARS AGO: THE INTERNATIONAL MAP 109

ANTIGEN-ANTIBODY COMPLEXES 110
G. C. Easty and E. H. Mercer

MICROSCOPICAL EXAMINATION OF METALLIC SURFACES 112
J. Nutting, M.A., B.Sc., Ph.D.

THE INTERNATIONAL GEOPHYSICAL YEAR: MONTH BY MONTH 118
Angela Croome

NEW SCIENTIFIC INSTRUMENTS 122

THE BOOKSHELF 124

SCIENCE ON THE SCREEN 129

FAR AND NEAR 130

COVER PICTURE: The cover this month shows the United Kingdom National Airways system correct as on January 1, 1957. The inset shows a photograph of the radar screen at London Airport. (See "Electronics in Civil Aviation", p. 100.) Details of the system of runways can be clearly seen. The drawing is based on information kindly supplied by the Ministry of Civil Aviation and Transport.

In the interest of *accuracy*

In the field of scientific photography, where performance must be capable of prediction and control within close limits, the consistently high quality of Ilford products has more than usual significance. This accounts for the regular use of Ilford sensitised materials by scientific and industrial research organizations, both great and small, in every part of the world.

ILFORD **PHOTOGRAPHIC MATERIALS**
in the Service of Science

ILFORD LIMITED ILFORD · LONDON

THE PROGRESS OF SCIENCE

NOBEL PRIZES FOR THE YOUNG?

The publication of a book called "Nobel Prize Winners", edited by L. J. Ludovici for Arco Publications, at 25*s.*, is an opportunity to assess the value of the prizes that have been awarded over the years to scientists of high repute. Another book on Nobel Prize winners was published for the Nobel Foundation by Sohlmans Forlag, Stockholm, in 1950, and reviewed in DISCOVERY, May 1951, p. 135.

No one can possibly either grudge or regret the honour and the material benefits bestowed upon Albert Einstein, Sir Alexander Fleming, Thomas Hunt Morgan, Heemann Joseph Muller, Lord Rutherford, Sir Charles Sherrington, and others who have made great contributions to human knowledge. It is, however, not inappropriate to remark, as Ludovici has done in his prefatory note, that a few months before his death Alfred Nobel said, "I would not leave anything to a man of action. Such a man would thus be tempted to give up work. On the other hand, I would like to help dreamers, who find it difficult to get on in life. Dreamers such as possess the gift of poetry, but are unknown to the many, or are misunderstood by them, meditative young research workers *who are on the very threshold of a great discovery in physics, chemistry or medicine, but lack the means to achieve it.*" (Italics ours.)

The difficulties of deciding which of the workers in laboratories all over the world may be "on the very threshold of a great discovery" are obvious. The money and the glory may very easily go to somebody apparently promising, whose work peters out in a blind alley; the genius may well be overlooked. Alfred Nobel was indeed fully aware of the difficulties, for in framing his will he worded it that "the said interest shall be divided into five equal amounts, to be apportioned as follows: One share to the person who shall have made the most important discovery or invention in the domain of Physics; one share to the person who shall have made the most important Chemical discovery or improvement . . ." and so on; thereby, in fact, annulling his clear wish that the awards should go to those "on the threshold" of discoveries.

Yet the wish remained, and it is sad to think that after Dr Werner Forssmann had made the experiments which endangered his own life, his work was deprecated, and two applications to the Notgemeinschaft Deutscher Wissenschaftler for financial assistance were refused; so that only last year, in middle age, he was at last awarded the Nobel Prize in Medicine. Fleming and Rutherford each received their Nobel awards when they were already respected and established figures in the scientific world. And Einstein's *annus mirabilis* (1905) passed unnoticed.

One would like to see the Swedish Academy of Science (which selects the winners in physics and chemistry) and the Caroline Medico-Surgical Institute (which selects those in physiology and medicine) coming out more boldly on the side of youth. How satisfied with his legacy Alfred Nobel would be if some young dreamer could by its aid be encouraged to pursue his vision; and how proud if he turned out to be one of the great ones of the world.

HERTZIAN WAVES

The centenary of the birth of Heinrich Hertz, which fell on February 22, recalls how very near he came to discovering x-rays and how he discovered Hertzian waves without any premonition that man would sooner or later use such waves for telegraphy or telephony. Hertz was a lawyer's son, and very early had to choose whether he would follow his father's calling, or take up a career in pure science or engineering. For a year he was an engineering apprentice at Frankfurt, an experience which no doubt helped him when he came later to construct apparatus for his electrical researches. He finally decided that natural science was to be his career, a choice which was soon justified when he won a prize for a dissertation he wrote during his period of military service.

In 1880 he became a demonstrator under Helmholtz at Berlin. He thus came under the influence of a master who was to urge Hertz to study the relation between electromagnetic actions and the polarisation of a dielectric, a subject sponsored by the Berlin Academy of Science. Hertz's three years with Helmholtz set him on the road to success; for so firm was the master's faith in his young assistant that whenever the former was asked a question on electrical theory, he would refer the student to "Dr Hertz, who has already arrived at the answer". From Berlin, Hertz went on to Kiel as Privatdozent for two years, and then in 1885 he became professor at Karlsruhe Technische Hochschule.

It was at Karlsruhe that Hertz made his classical experiments which produced electromagnetic waves between two coils, these following his studies based on Maxwell's electromagnetic theory. He had found in an old store-room two flat coils insulated with sealing-wax, the second of which he provided with a spark gap. On using a Leyden jar to pass an electrical discharge through the first coil, Hertz noticed a spark jump across the gap in the second coil. Further, in a nearby conductor he also noted the appearance of side sparks; hence on investigating he found a neutral point in this conductor and concluded that he was dealing with oscillations. Hertz's original apparatus for this classic experiment was preserved in the Deutsches Museum at Munich.

To appreciate Hertz's rôle in this period which led to radiocommunication in years to come, it is necessary to know something of the contributions of other workers. In 1842 Henry had noted the oscillatory nature of a condenser discharge in association with self-induction. Kirchhoff, in 1857, had studied the effect of self induction in association with capacity in a telegraph-line, and in 1864 Maxwell had predicted that electromagnetic waves existed moving at the speed of light. Then in 1870 came results unknown to Hertz, but which he acknowledged later to be closely related to his own. Von

On the opposite page is reproduced the original MS. of Hertz's classical paper printed in *Sitzungsber. d. Berl. Akad. d. Wiss.*, December 13, 1888, and *Wiedemann's Ann.*, vol. 36, p. 769. This MS. is now in the Science Museum, London, to which it was presented by Frau Hertz. Both the portrait of Hertz and the MS. are reproduced here by kind permission of the Director. Below is a translation:

ON ELECTRIC RADIATION

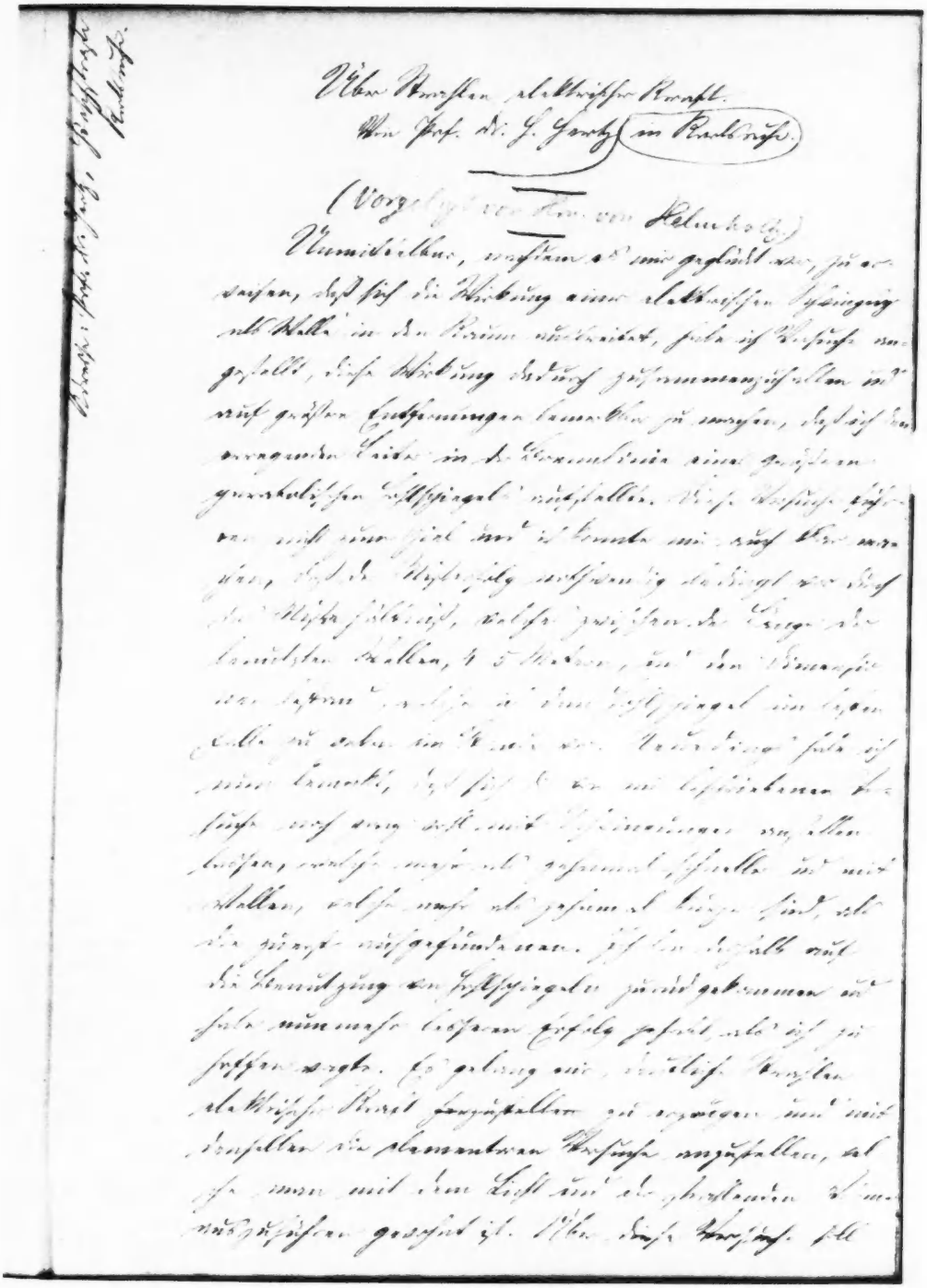
(Communicated by Herrn von Helmholtz)

As soon as I had succeeded in proving that the action of an electric oscillation spreads out as a wave into space, I planned experiments with the object of concentrating this action and making it perceptible at greater distances by putting the primary conductor in the focal line of a large concave parabolic mirror. These experiments did not lead to the desired result, and I felt certain that the want of success was a necessary consequence of the disproportion between the length (4–5 metres) of the waves used and the dimensions which I was able, under the most favourable circumstances, to give to the mirror. Recently I have observed that the experiments which I have described can be carried out quite well with oscillations of more than ten times the frequency, and with waves less than one-tenth the length of those which were first discovered. I have, therefore, returned to the use of concave mirrors, and have obtained better results than I had ventured to hope for. I have succeeded in producing distinct rays of electric force, and in carrying out with them the elementary experiments which are commonly performed with light and radiant heat. About these experiments. . . .

Bezold had been studying the behaviour of electrical discharges after springing across a gap and also the reflection of electrical waves from the end of a wire along which they were sent. It remained for Hertz to tie up several loosely connected points or ideas, to unite them, and to adopt into his great study such observations as those of Heaviside and Poynting: that when currents are induced in a secondary circuit by oscillations, then the effect takes place in the dielectric. Hertz found that a metal sheet placed around the secondary would screen it even if it were only of the thickness of tin-foil. He found that ultraviolet light falling on a spark gap too wide for a discharge would cause ionisation and thus permit the spark to pass. He studied dielectrics, and noted that the distances between the coils did not introduce the law of inverse squares into the results as had at first been guessed. In concluding that electric waves were transmitted from one coil to the other with a speed of the order of light, he used a transmitting distance of 12 metres, then considered big. Hertz thus established in a practical manner the electromagnetic theory of light; for he found wave-lengths, showed vibrations to be transverse, and (with his parabolic mirrors of sheet zinc and his prism of pitch) showed reflection and refraction. Although he used such terms as "the sender" for his oscillator and "the receiver" for his second mirror, no thought of possible use for electrical communication came to his mind. His Hertzian waves had caused a sensation in the world of science, yet the general view was that of Lodge, who failed to see any practical advantage in telegraphy across space! Even when reference was made by Crookes in 1892 to the idea of "tuning" to particular wave-lengths (this after he appreciated that a "harmony" or resonance could be caused between the two circuits), the wireless age was seemingly as far off as ever.

Yet if Hertz was too early for radiocommunication, how much nearer he was to the discovery of X-rays. At Bonn, where he had succeeded Clausius, he continued some experiments on a second theme of his, namely the discharge of electricity through rarefied gases. Bonn had acquired fame for the work of Geissler, Hittorf, Plücker, and others at that university, while Hertz also had Lenard as colleague. Thus it was that Hertz was led to show how cathode rays penetrated thin plates of metal, while Lenard put a metal "window" to permit the escape of rays from the vacuum tube, rays which escaped as "Lenard rays". But it was left to Röntgen to add that little extra and give us X-rays.

Hertz published classic texts on Electric Waves and their Propagation, and on the Principles of Mechanics. He was awarded the Rumford medal of the Royal Society. Hertz died at the early age of 36 on January 1, 1894, unaware that the Hertzian waves which had



perpetuated his name were shortly to bring about a revolution in the art of communication. Wireless telegraphy, broadcasting, and television have all developed directly on the foundations he laid so surely.

Although Hertz died at such an early age, his widow survived him for many years, and his two daughters are still living in England. Hertz was of Jewish extraction and, finding conditions of life in Germany under the Hitler regime intolerable, his widow and daughters came to live in Cambridge in 1937. Finding refuge and peace here, his widow, Frau Elizabeth Hertz, generously presented the original manuscript of one of her husband's most famous papers on electric radiation to the Science Museum, South Kensington. Frau Hertz died in 1942, but her two daughters still live quietly in Cambridge, grateful for the shelter and protection which has been given them and seemingly unmindful of the great debt which the world at large owes to their father's memory, which as yet remains unpaid.

GIANT OIL TANKERS

The largest cargo-ship in service today is an oil-tanker, and it may not be long before a tanker is the largest ship of any kind in the world. The remarkable growth of tanker fleets, the combined gross tonnage of which now makes up a quarter of the world's merchant ship total, has been the dominant feature of the post-war shipbuilding and shipping industries. The spectacular increase in the size of the largest tankers during the past five years has astonished even those industries, and it is not surprising that it has recently attracted so much public attention. Before the war a tanker able to carry more than 12,000 tons of oil was a rarity. Five years ago a deadweight capacity of 30,000 tons earned the title "super-tanker"; today 60,000-ton tankers are no more than "large", and "giant-tankers" to carry 100,000 tons at a time have been ordered from Japanese and American shipyards.

This rapid and dramatic increase in size—which is certain to continue for some time yet—is not due to any sudden technical advance in shipbuilding, nor to a sudden realisation that bulk cargoes such as oil are most cheaply carried in very large units, but almost entirely to changed world economic conditions.

Oil-tankers are a part of the vast, world-wide oil industry; they have been aptly termed "floating pipelines", and their fortunes are closely linked to those of the industry as a whole. In the unstable, depressed pre-war 'thirties, ships of all kinds were laid up for long periods, and the obvious financial risks of putting too many eggs in one basket effectively limited the size of tankers. However, rapidly and steadily expanding world trade in recent years has altered the economic background significantly. Even more important, the continually growing demand for oil and its products in industrial countries, which is so marked a feature of the post-war world, has made these countries far more dependent on oil than ever before. The new and vastly expensive refineries in Europe and North America must be fed with oil, most of which has to be brought across oceans. The feeling of long-term confidence in oil has been shared by many shipowners, and they have spent hundreds of millions of pounds on new tankers. All the same, there are still plenty of financial risks in carrying oil by sea; it is very susceptible to the slightest shifts of prosperity, and in September 1954 over four million deadweight tons of oil-tankers were laid up temporarily. But confidence returned with redoubled vigour, and for the past two years the shipyards of the world have been overwhelmed with orders for more and larger tankers.

It is probable that the size of tankers will continue to increase so long as they can be designed, constructed, and operated with reasonable economy and efficiency. The basic design of very large tankers presents few difficulties; their hull forms are simple and orthodox, since they are essentially slow-speed ships in relation to their length (even a 20-knot tanker would be technically a "slow" ship if 1000 feet or over in length), and in consequence machinery powers for their propulsion are not high compared with those for other large ships, such as passenger liners. Structural design is also fairly straightforward, but the construction of tankers much larger than those now on order does present several awkward problems. Tankers have different overall proportions from passenger liners (in particular, their length-depth ratio is greater), and in consequence much of their hull structure has to be appreciably thicker. In addition, a larger margin against corrosion has to be allowed; the overall effect is that many extremely thick steel plates are needed. Not only does this impose extra demands on steel-mills, but plates two inches and more in thickness cannot be readily shaped or welded in shipyards. Welding is, of course, the best method of assembly for large tankers, but it can only be used efficiently if large units can be prefabricated in special welding-sheds and then hoisted into position on the building-berth, where the hull is formed by joining together a comparatively small number of large blocks. Prefabricated units weighing up to at least forty tons are clearly going to be required, and few shipyards are yet equipped to make such units or to move them from shed to berth. Further, there are very few building-berths large enough to handle ships over 1000 feet long and 130 feet broad. Here the great beam of future giant tankers is the critical feature, for it is much more difficult to increase the breadth of a building-berth than to lengthen it, and the task may indeed involve combining two adjacent narrow berths into a single broader berth. None of these constructional difficulties is insuperable, but to overcome them will require, among other things, very heavy capital expenditure in shipyards to carry out the necessary alterations, which must be made without seriously interrupting the urgent work already under way.

The efficient operation of giant tankers also does not have serious technical difficulties, but requires even greater capital investment to provide the necessary harbours and other essential facilities. Ships 1000 feet long, having draughts of well over 36 feet, can serve on a very limited number of useful routes (there is little likelihood, for instance, of taking giant tankers through

any of the world's canals), but, even so, new or enlarged deep-water terminal facilities will have to be built. Similarly, still more expensive dry or floating docks, larger than anything yet available, will be required for repairs and maintenance.

The size of the largest tankers and the way in which they are operated may soon also be influenced by the introduction of atomic propulsion for merchant ships. Nuclear reactors suitable for marine engines are now being intensively developed, and an experimental prototype may be built on land by the U.K. Atomic Energy Authority this year. When atomic ship propulsion is adopted commercially it is very probable that it will first be applied to the largest tankers, partly because atomic engines will be heavy, and will therefore naturally be most suited to large ships. Further, atomic propulsion will be most advantageously used in ships such as tankers, which spend only short periods in port, for only then can the fullest use be made of machinery likely to have high capital cost and comparatively low running costs. Since the efficient marine nuclear power plant is likely to be a high-power unit, the speed of atomic-engined giant tankers may well be significantly greater than that of present conventionally powered similar ships.

On balance it seems clear that the long-term advantages of giant tankers are sufficiently marked to make it highly probable that the 100,000-ton tanker will not long remain the largest afloat; while the ship to carry 500,000 tons of oil at a time will be unlikely to leave the drawing-board, the 150,000-ton tanker, or perhaps even the 200,000-ton ship, will one day bring oil from the Middle East to Europe and America—round the Cape of Good Hope.

EXPERIMENTAL BRAINWASHING

At McGill University, Montreal, and at the National Institutes of Health in Washington, experiments have recently been carried out which have important, if disturbing, implications for the understanding of human behaviour. In work undertaken for the Canadian Board of Defence, Prof. Donald Hebb, of the Psychology Department at McGill, has tested the limits of the human adult's endurance of stimulus starvation. Sixty university students, healthy and apparently stable, were paid twenty dollars a day for as long as they could bear to remain on a bed in an air-conditioned box. Their eyes were covered with opaque goggles, and their arms and hands were restrained by cardboard sleeves. They had food and could go to the lavatory, but except for receiving some experimental instructions by microphone, they saw and heard no one. Perhaps most crucially, they were cut off from self-stimulation: for the opaque goggles and the arm restraints interfered with the silent flow of "body-talk" which we carry on with ourselves, even in sleep.

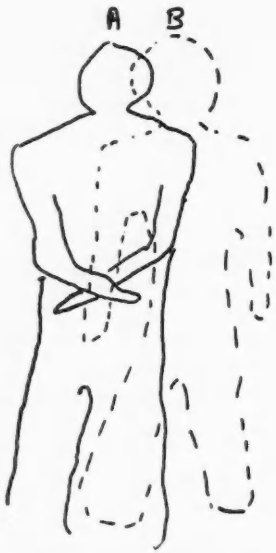
Hebb found that few subjects could stand these conditions for more than twenty-four hours, at most seventy-two hours: three days and three nights. Many subjects broke down emotionally, and hallucinations were frequent.

The hallucinations seem to have been similar to those seen by subjects who have been given mescaline or lysergic acid, and a series of increasing complexity could be distinguished as time went on. At first there was simply a change in the overall colour of the visual field—from dark to light; then came dots of light, lines, or simple geometrical patterns. Only after some time did this "wall-paper" type of visual imagery give way to complex scenes and figures (such as a row of little yellow men with black caps on and their mouths open, a procession of squirrels marching "purposefully" across the snow and out of the visual field). Some subjects hallucinated with other senses than sight. One, for example, could always hear people talking; another was haunted by the sound of a musical-box. One man reported seeing a miniature rocket-ship discharging pellets that kept striking his arm; and one reported reaching out to touch a door-knob he saw before him and feeling an electric shock. In two cases a strange kinaesthetic impression occurred, in which the subjects abandoned the reality of their isolation in the cubicle, and felt as if they were two people, lying side by side. Other changes in the body-image might have come from "Alice in Wonderland": one subject said his mind seemed to be a ball of cotton-wool floating above his body; another that his head felt detached from his shoulders.

Other experiments in which stimulation was severely restricted have shown that early phases of the process can be pleasurable. Dr John Lilly, at the Washington Clinical Centre of the National Institutes of Health, using himself as guinea-pig, reported that when first submerged upside-down in a tank of water at body temperature, he felt happily relaxed, and floated as if in air. Naked, his head enclosed in a blacked-out mask, hearing and seeing nothing, he enjoyed a state of uterine bliss for the first hour or two, dozing off into a peaceful sleep. When he woke up, however, he began to be troubled by compulsive thoughts; the same ideas recurred in a stereotyped way, as if in a closed circuit. As in the Canadian studies, Lilly found that anxiety soon set in, hallucinations, and finally a state of terrifying, complete disorientation.

It appears from these studies that lack of incoming stimulation soon breaks down the human being's capacity to test reality—that is, to distinguish between a percept which is aroused by an object actually present to the senses, and an image or thought which is aroused from within the mind. The hallucinated patient reaches out to grasp the object he "sees" in the empty air, as the small child tries to catch the images which appear before his eyes after he looks from sun to shadow. From birth onwards it takes a long series of personal experiments in reality-testing before we can reliably discriminate between fact and fantasy. Moreover, we have ample evidence from the findings of psychoanalysis that when fantasy is untempered by reality, as in severe psychosis, emotions are intense, overwhelming, and uncontrollable.

Even more disturbing than the ease with which a normal person can be induced to regress in thought and emotion by lack of stimulus input, is the effect of the

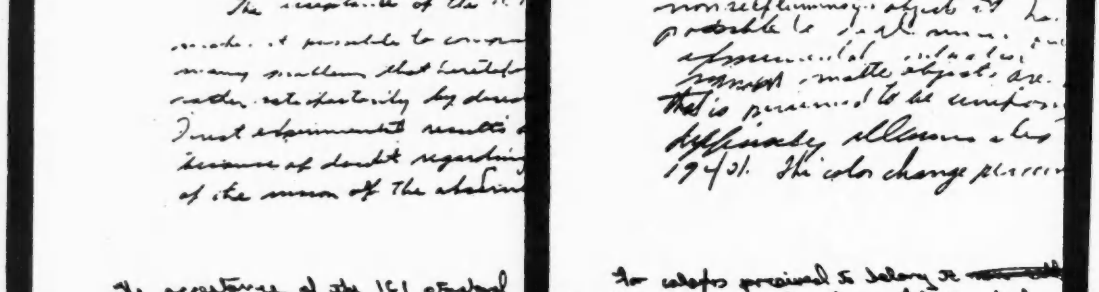


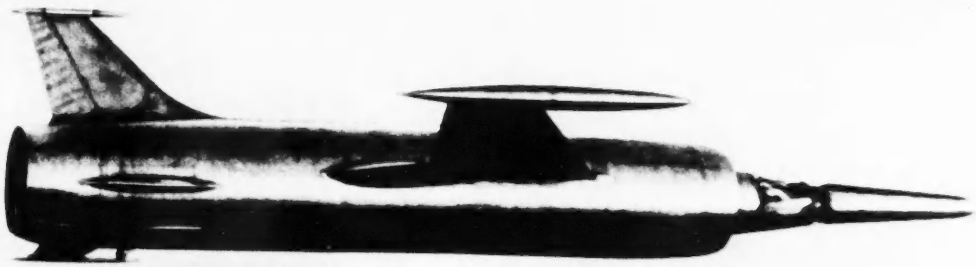
Left Drawing made by a subject to show how he felt at one period in the cubicle. He reported that it was as if "there were two of me", and was momentarily unable to decide whether he was A or B.

Below Specimens of handwriting before and after the isolation period. (From an article by Bexton, Heron and Scott, *Canad. J. Psychol.*, 1954, vol. 8, 70, published by kind permission of the authors and the journal.)

first stimulus received afterwards. Starved of his usual mental food, it seems that man will eat whatever is offered him. Once a person has reached the stage of complete disorganisation and disorientation, he will accept readily any new information which is given him without putting it through the testing process of judgment. In other words, the participants in these experiments were highly suggestible when first restored to human society.

We need no longer be surprised, therefore, to learn that innocent prisoners confess to crimes they could not possibly have committed, and that such confessions are obtained without the use of physical violence. The mental torture of prolonged isolation in a darkened room, especially if this be combined with lack of sleep, will soon produce a mental state in which personal identity is lost or undermined. Under such conditions, emotional response becomes uncontrolled and painful, and the acceptance of ideas from others, whoever they be, becomes preferable to being haunted by the ghosts of the unconscious, ghosts which in normal life we allow to appear for moments only in those transitory hallucinations of sleep: our dreams.





FRENCH RAMJET REACHES 1242 M.P.H.

A sidelight on alternative approaches to the problem of ramjet research is given by the news that a Leduc ramjet aircraft has flown at supersonic speeds. The ramjet is pre-eminently an engine for supersonic flight, reaching its best performance at Mach numbers between 3·0 and 4·0. The news from France (coming a few months after glimpses afforded by the 1956 SBAC Show of British ramjet-research) points to a comparison between, on the one hand, the missile approach, in which, even in its earliest flights, the test vehicle is rapidly accelerated to supersonic speed by rocket boost, and on the other the piloted-aircraft technique in which an advance to supersonic flight is made only when sufficient ramjet experience has been gained from tests in subsonic flight.

M. Leduc's aircraft approach to the problem has been possible theoretically because, even at high flight Mach numbers, the flow of air within a ramjet is subsonic at all stages except at the point of expansion in the exhaust nozzle. The engine, in common with a number of other internal combustion engines, works on the constant pressure cycle. Compression is achieved by skilful design of the air-intake system to recover the dynamic head (the ram pressure from which the unit takes its name) set up by the speed of flight. The recovery of pressure by reduction of air speed is continued in the air intake diffuser until the speed is low enough to support combustion in the main burning zone. The flame is sustained by a kernel, or pilot zone, established in the wake of a stabilising baffle, and much of the art of combustion chamber design lies in the ability to compromise between good flame stability and the pressure losses incurred in achieving it. Since a ramjet may burn at fuel/air ratios as rich as the chemically correct mixture, combustion temperatures are high and there is a considerable problem in developing a flame pattern which avoids excessive heat transfer to the chamber walls.

These problems can usefully be investigated in a subsonic aircraft, but the temperature at inlet to the combustion chamber, low by comparison with values in supersonic flight, raises a problem of its own in its effect on fuel vaporisation.

Expansion of the exhaust in a subsonic ramjet takes place at a low-pressure ratio so that only a convergent nozzle is needed and the exhaust is everywhere subsonic. At higher speeds, pressure ratios well above the critical are attained and a convergent-divergent nozzle is used in which the exhaust becomes sonic at the throat and supersonic downstream of it. This cannot be simulated in subsonic flight tests.

To establish the basic design for a missile type of ramjet test vehicle, elaborate ground-testing facilities are needed. The capital expenditure involved is consequently vast, but it is known that British test vehicles were propelled by ramjets at supersonic speeds as long ago as 1951. It will be interesting to see how much the advantage of having a human observer in flight tests will broaden our knowledge of the art of ramjet design.

A NEW NAKED-EYE COMET

"Old men and comets," wrote Jonathan Swift, "have been reverenced for the same reason: their long beards and pretences to foretell events." Since Swift's time our picture of these "heavenly visitors" has undergone many changes. We no longer believe that they indicate future events, except in the purely astronomical sense of presenting us with information from which their future motion in space may be computed. Moreover we now call their "hairy" appendages "tails", not beards. But astronomers still observe them avidly for there is still much to be learned of their nature and origin.

Unfortunately for everyone concerned a comet seldom appears as a bright, naked-eye object. Usually it can be seen only in a telescope and always observations have to be made near perihelion, that is, when the comet is in that part of its elliptical orbit nearest to the Sun. At other times a comet is not visible, even in the largest of telescopes. Naked-eye comets, which are calculated to interest and surprise everyone, seldom appear. The return of Halley's comet in 1910 is the most notable example in this century of one of naked-eye visibility, while the most recent visible without a telescope appeared in 1947, but could be seen only in the southern hemisphere.

British astronomers have recently become very much interested in a comet discovered by Arend and Roland last November. Photographs taken in January, when the comet was some 232 million miles from the Sun.

showed it to have a very concentrated head and a tail of some size. The brightness of the head of a comet and the size of its tail is dependent not only upon the quantity of material of which it is composed, but also upon the closeness of its approach to the Sun. This is, of course, due to the solar energy received by the cometary material. This energy causes it not only to reflect sunlight but also to emit incandescent material from which the tail is formed. The comet thus becomes visible. At a distance from the Sun of over 200 million miles, comet Arend-Roland is conspicuous enough to cause comment. As it will approach within 31 million miles, or a third of the Earth's distance from the Sun, astronomers expect that it is likely to become a very bright, naked-eye object. In England it will be visible in April after it has passed perihelion. At first only its tail will be seen, but as it moves across the sky on its journey away from the Sun the whole of the comet will be visible in the eastern sky just before sunrise. It will be at its brightest on April 10–12, and certainly will be worth looking for. It may well turn out to be "the great comet of the century".

NEPTUNE'S HORSES

The sea-horse, with its horse-like head and shoulders and its free-turning neck, its bony finless tail and upright stance, looks unlike any fish, yet it breathes by means of gills, and swims by means of fins, and it lives on larvae and tiny shelled organisms: it is as much a fish, in fact, as a trout is.

The sea-horse is found in tropical and warm temperate waters. It is common in the Mediterranean and in the warmer parts of the Atlantic, less so in the English Channel, and is found occasionally but rarely in the North Sea. It is a gregarious creature. A quaint underwater sight is a school of them swimming along, grasping each others' tails affectionately and performing what looks like a ballet. The sea-horse swims in a vertical position, head uppermost, propelling itself by rapid fluttering of the pectoral and dorsal fins.

An unusual aspect of the sea-horse's life is its manner of reproduction. The male bears the young, eggs being laid in a pouch under his tail, whence the young eventually emerge. The photograph here reproduced was taken by Jack de Cuziat of Paris, and shows the pouch almost on the point of giving birth.

The unusual appearance of the sea-horse is its best protection against natural enemies. The upstanding horns around head and neck, and the bony rings with which the body is circled, give the appearance of seaweed, so that when it grasps a stem with its prehensile tail and sits quite still, it is as effectively camouflaged as a chameleon.

FLAMSTEED'S WELL

The Observatory, vol. 76, No. 890, contains an interesting article on Flamsteed's Well by P. S. Laurie, Royal Greenwich Observatory, Herstmonceux Castle, and also two other papers on the same subject. Laurie draws attention to the popular legend that John Flamsteed—the first Astronomer Royal (1676) and first known as the Astronomical Observator—sank a well at the Royal Observatory so that he could better observe stars by day. The true facts, however, are that Flamsteed wanted to make accurate observations of γ Draconis, which passes close to the zenith at the latitude of Greenwich, and that a well seemed to be the most effective method for obtaining stability with a long-focus telescope of about 87 feet. The existence of this well has been the subject of controversy, but in 1903 some correspondence between Maunder and Lynn (two well-known astronomers in those days) which was published in *The Observatory*, vol. 26, pp. 102, 138, 179, showed that it did exist, and in 1862 Airy had collected information about its site. He located this a short distance south-east of Flamsteed House, and his view was strengthened by a subsidence there in 1881.

Flamsteed mentioned the well in a letter to his patron, Sir Jonas Moore, in 1677, and remarks made in this letter almost certainly refer to fixing an object glass and making allowance for its adjustment. On July 30, 1679, Flamsteed himself noted that in the subterranean pit he had clearly observed a transit in the head of the Dracon.

Under the title "The Flamsteed 90-foot Lens", A. Hunter and E. G. Martin (on the staff of the Royal Observatory) give a detailed description of the lens which Dr H. R. Calvert, the Science Museum, South Kensington, kindly allowed them to examine. Their test showed that the lens is of very poor quality, and it seems that its one recorded use was sufficient to make Flamsteed discard it.

A short note under the title "Daylight Visibility of Stars Through a Long Shaft" appears in the same issue of *The Observatory*, and gives a summary of Alex. G. Smith's paper with the above title, which was published in *J. opt. Soc. Amer.*, 1955, vol. 45, No. 6. He shows that there is no experimental evidence or indeed theoretical justification for the commonly held belief that bright stars can be seen in daylight by looking up a long chimney or well-shaft. In no cases where practical tests have been carried out has there been confirmation of this view.

It is pointed out that such an effect, if it exists, must have either a physical or physiological explanation, and the only explanation of the former would be the contrast between star and sky undergoing an increase by a lowering of sky brightness as seen through the chimney. This view is, however, negatived by experimental evidence; photometric comparisons of zenith sky brightness measured inside and outside a 157-foot chimney showed no significant difference. A physiological explanation could be given if the shielding of parts of the retina resulted in greater dark-adaptation and contrast appreciation, but experiments do not support this view. In fact the opposite occurs; numerous investigations by laboratory tests show that contrast sensitivity is actually *impaired* when the test field consists of a small luminous area in the middle of a large, dark surround. A considerable lowering of the contrast threshold results from increasing the luminance of the surround until it approximates to that of the test field. The conclusion is

Excessive foaming in a sewage works.

that "everything indicates that the belief in the daylight visibility of stars through a long shaft is without foundation".

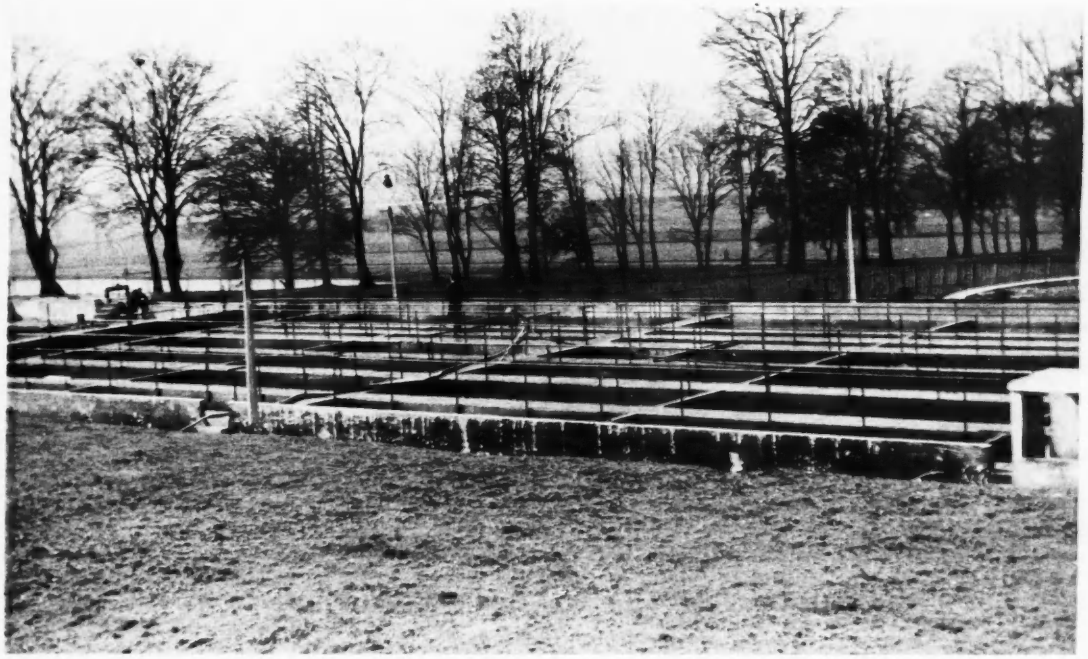
SYNTHETIC DETERGENTS AND FOAMING IN SEWAGE

A recent publication* on the use of silicones for preventing foaming contains two photographs of the aeration tanks at a sewage works using the activated sludge process; in one they are covered by a thick layer of white foam, and in the other this has been supressed by adding a small quantity of a silicone antifoam to the sewage. Other types of defoamant have also been used successfully in attacking this modern problem of the sewage works manager; at the Mogden Works of the Middlesex County Council, for example, foaming, which has at times been spectacular—it has reached a height of some 10 feet—has been cured by adding organic defoamants based on petroleum oils. At this works, which serves a population of some 1½ million people, the annual cost of the defoamant is expected to be of the order of £15,000, equivalent to about 2½*d*. per person per year. Although foaming has been troublesome at most sewage works during the past few years, it has not generally been a major problem at those plants (serving some 22 million people) in which the biological stage of purification is brought about in percolating filters. In this process the sewage, after sludge has been separated, is passed downwards through beds of stones or other hard material, on the surface of which an active bacterial and fungal flora develops, the large quantity of oxygen used in oxidising organic matter and ammonia being absorbed from the interstitial air as the liquid trickles in thin films through the bed. The chief troubles have been at works (serving about 12 million people) employing the more modern activated sludge process in which the settled sewage, mixed with biologically active sludge, is passed through deep channels, where it is aerated mechanically or by diffused air—conditions which are ideal for the formation of foam on the surface. At works using this process a great deal of effort has been applied to finding a cure, for foam is not only a nuisance and a danger to public health (it blows away, taking bacteria with it) but it makes maintenance of the plant difficult, sometimes impossible, and always dangerous.

Foaming, on the scale on which it has occurred during the past few years is, of course, due to the presence in the sewage of synthetic detergents, the consumption of which, for domestic use, has more than trebled since 1949. Although interference with sewage purification by foaming is their most visible effect, there are other, and perhaps more important, ways in which they may affect the public health services; the evidence was reviewed in the report,* issued last year, of the Committee, under the Chairmanship of Sir Harry Jephcott, which examined the question for the Minister of Housing and Local Government.

* "Silicones for Foam Prevention", Nobel Division, ICI.

* Ministry of Housing and Local Government. "Report of the Committee on Synthetic Detergents", H.M.S.O., London, 1956.



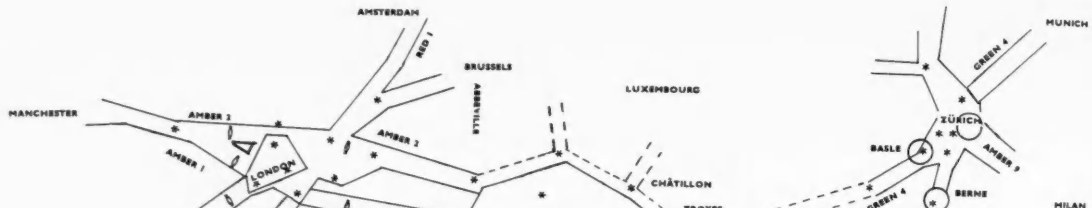
Foaming in sewage can be effectively suppressed by a spray of dilute silicone antifoam agent.

Modern domestic detergents contain anionic surface-active agents of the alkyl benzene sulphonate type, which are comparatively resistant to bacterial attack; of the material present in sewage, a part—often about half—passes through a sewage treatment plant and is discharged with the effluent. There is no evidence, either from this country or abroad, that the capacity of bacteria at sewage works to decompose alkyl aryl sulphonates has increased since modern detergents were introduced. About a quarter of the population is supplied with water taken from rivers to which sewage effluents have been discharged upstream of the intakes. This water is of course treated at water works before it is distributed, but the processes used cannot be relied on to remove surface-active agents completely. It is known that some river waters used for domestic supply contain small concentrations of these substances—usually less than 0·5 p.p.m., but occasionally rather more—and their possible effect on public health is therefore important. The Committee referred to found no evidence that such small quantities could cause any ill effects, but they recommended that the situation should be carefully watched, regular analyses being made of water taken for public supply from rivers to which sewage effluents have been discharged.

Another point of interest is that alkyl benzene sulphonates, even in very small concentrations (certainly down to 0·1 p.p.m.) considerably reduce the rate at which deoxygenated water will absorb oxygen from the air. Their presence in sewage effluents may for this reason be important, since the minimum concentration of dissolved oxygen in a stream polluted by such an effluent (a quantity, amongst other things, important to fish) will fall if rate of reoxygenation falls. Finally, there is evidence that the quality of some sewage effluents has deteriorated since synthetic detergents were introduced—a change which may prove to be connected with their property of reducing the rate of absorption of oxygen by liquids.

Clearly, most of the difficulties which synthetic detergents have caused would disappear if they were destroyed in passing through a sewage works. Work is therefore going on in several parts of the world in an attempt to develop substances with satisfactory detergent properties, which can be produced at an economic price from available raw materials, but which are readily decomposed by bacterial action. It has been shown that substances of the alkyl aryl sulphonate type are more easily attacked if the alkyl chain is straight rather than branched. There are possibilities also of developing suitable surface-active agents from quite different raw materials—certain monoesters of sucrose, for example, were recently reported to be promising.

During the middle of January 1957 the Minister of Housing and Local Government announced that he had set up an advisory committee, with Mr. H. W. Cremer as Chairman, to keep under review any matters concerned with the impact of domestic detergents on the public health services; they should find many interesting matters for discussion during the next few years.



Pattern of Airways between London and Zürich.

ELECTRONICS IN CIVIL AVIATION

J. C. FARMER, B.Sc., M.I.E.E.

Deputy Director of Telecommunications (Development), Ministry of Transport and Civil Aviation

The task of moving large numbers of passenger aircraft at high speeds between all the important cities of the world involves the rapid exchange of information. Before beginning his flight the pilot needs to know the weather and the state of the various ground facilities. He requires, if possible, a general assurance that his progress will be free from collision hazard. Even more important is that he shall know, during his flight, any changes in the information available to him at take-off. While he is flying he needs further information, either from his own navigational instruments or from the ground, taking into account any adverse weather conditions he may meet. Such is the tempo of modern flying that all this information should preferably be presented to him in such a form that he is shown or told precisely what to do; for example, what track to follow, what distance to go, what correction is needed to height or speed.

The ground authorities are equally exacting in their requirement for information. Before the aircraft leaves the ground, they must be given full details of its load and proposed route. While it is in flight, they must follow its progress and be able to communicate with it at all times. They are also very dependent on receiving from the aircraft information concerning any intended changes of route and details of the weather. At the terminal airport, there will also be many interested parties, including Customs, Health and Immigration authorities, catering and ground transport staff, to say nothing of passengers' relatives who are equally desirous of knowing the progress of the plane, particularly during the later stages of its flight. Finally, the airline company itself, which bears an overall responsibility for the aircraft and its passengers, requires much of the information discussed above, and other information relative to the regularity and the economics of the flight.

Some of these idealised requirements are not yet satisfactorily met, particularly in the less developed areas of the world, but where the traffic density is greatest, as in the U.S.A. and in Europe, very great progress has been made in meeting the needs.

CIVIL AVIATION TELECOMMUNICATIONS TODAY

We will examine two typical and commonly flown international routes, in order to see how these requirements are met.

A medium-distance flight of 500 miles over Europe, as, for instance, Zürich to London, will take about 2 hours 20 minutes in a fast, modern aircraft like the Viscount. Information on a flight of this length must be available within 28 minutes from its time of origin, and the transit time of important safety messages must be very much shorter.

The Briefing Office at Zürich will have up-to-the-minute information on the actual and predicted weather at all airports and alternatives to which flight may take place, the weather along the routes to be flown, and the state of all facilities likely to be required if not in accordance with published information. All this data will arrive, generally by land-line or radio teleprinter over a world-wide exclusive civil aviation network with its own procedures and priorities.

The pilot will prepare his flight plan indicating his proposed route and altitude, together with other relevant information; and this, after clearance by Air Traffic

Control, will be sent to London and other interested airports and control centres along the route, using the teleprinter system already mentioned.

Once he is airborne, the pilot may have the choice of several means of communication with the various Air Traffic Control authorities over whose territory he is flying. He will probably be carrying a high-frequency transmitter/receiver with a number of pre-tuned crystal channels capable of operation either on radio-telegraphy or on radio-telephony, the latter being preferred when a satisfactory service is available. For most of the time, in western Europe, he will be speaking by means of a multi-channel very-high-frequency transmitter direct to the controllers. Although the range of the latter mode of communication is usually little more than optical, long ranges of 100–200 miles are now often obtained, partly because of the increased heights at which aircraft fly, but also because the ground stations may be sited on high ground. On these very high frequencies, 118 to 132 megacycles per second, speech is of a better quality and freer from interference and distortion than with high-frequency transmission.

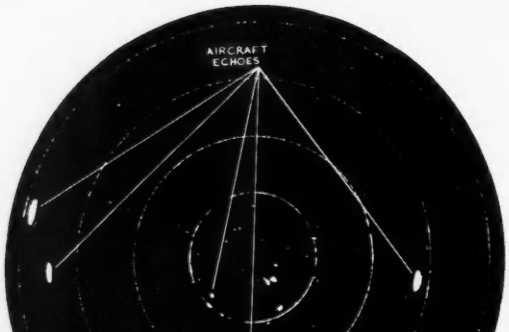
As the aircraft proceeds along the airways of Europe it will be guided mainly by certain types of navigational aid standardised all over the world. The commonest aid still in use is the airborne automatic direction-finder or radio compass, used in conjunction with medium-frequency ground beacons, or four-course radio ranges. The former are non-directional, and the latter often have their courses aligned along the airways, particularly where they intersect. At various points on the airway there may be marker beacons operating on 75 megacycles per second and beamed vertically upwards. The ground beacons are gradually being reinforced, and will eventually be replaced by the Very-High-Frequency Omni-Directional Range (VOR). Using the appropriate airborne receiver, the pilot may select any desired bearing, and his meter will show any deviation from the selected bearing. He will normally receive no indication of the distance he has travelled or that he desires to go, although he may calculate his position by taking bearings on a number of ground ranges, if they are conveniently situated. A suitable distance-measuring equipment working in the 1000 megacycles-per-second band has been standardised and developed in the U.S.A. and in this country, but for various reasons has not yet come into common use. A less complex distance-measuring equipment, working in the 200 megacycles-per-second band, is in use by a few airlines along the Eastern and African routes.

It is also the case that a highly accurate fixing system, operating in the low-frequency band between 70 and 130 kilocycles per second, already covers a large part of Europe and can be used by aircraft suitably fitted. This is the Decca Navigator System, and although extensively used by ships, it has not yet been standardised for aviation. It is used at present by the British European Airways Corporation, some of whose aircraft are also being additionally fitted with a device known as the Decca Flight Log. The normal method of presenting Decca information to the pilot or navigator is by means of meter readings which must be interpreted by special charts. With the flight log, however, the pilot sees in front of him a map of the country over which he is flying, on which may be superimposed the airway or track he wishes to fly. A moving pen traces his actual course with considerable accuracy, and in the most favourable conditions his position may be within a few yards of that indicated. The ground element of the system consists of a number of transmitter stations, usually four, grouped together to form a chain.

As the aircraft flies over various control sectors and zones, its passage may also be noted by ground surveillance radar, usually working in the frequency bands of 600, 3000 or 10,000 megacycles per second. When it is approaching to land, on the last 40–50 miles of its flight, it will receive additional guidance from radar and other navigational aids. A surveillance radar, continously rotating, will have picked up the aircraft perhaps 60 or 100 miles away, if it is flying high, and it will be guided towards a point from which it may make its final approach to land. Up to this stage, however, the radar service will have been performing largely a monitoring function, the aircraft navigating itself over various beacons and markers until it reaches a suitable point for vertical "stacking", if bad weather or traffic congestion makes this necessary. In order to identify itself on the radar, the plane may have been asked to execute some simple manœuvre which would be observed on a ground automatic direction-finder working in the very-high-frequency band, and a radar height-finder may also have given a check on its altitude.

For the final approach to land the pilot has a choice of two systems. He can fly on what is known as the Instrument Landing System (ILS), which consists of a ground transmitter (the Localiser), operating in the frequency band 108–112 megacycles per second, and providing horizontal guidance along a beam. Vertical guidance down a glide path at an angle of approximately three degrees is provided by another transmitter (the Glide Path), operating in the band 328–335 megacycles per second. Associated with this system are one or two marker beacon transmitters along the extension line of the runway, and operating on 75 megacycles. These have aerials beamed vertically upwards and give a characteristic audible note to the pilot when he passes over them. Another airborne receiver picks up the signals from the localiser and glide path, and the pilot is able to see his progress in relation to the horizontal and vertical beams by means of a meter.

The second system of approaching to land, known as the Precision Approach Radar (PAR), requires no equipment to be carried in the aircraft. A ground radar having oscillating horizontal and vertical aerials, displays the exact position of the aircraft in relation to its correct and safe path of approach. Oral instructions are then given by the radar controller to the pilot advising him of the course he should fly and the extent of any discrepancies. The radar operates on 10,000 megacycles per second, and is, of course, designed to be extremely accurate. The PAR is more commonly known as the "talk-down" system and, like the ILS



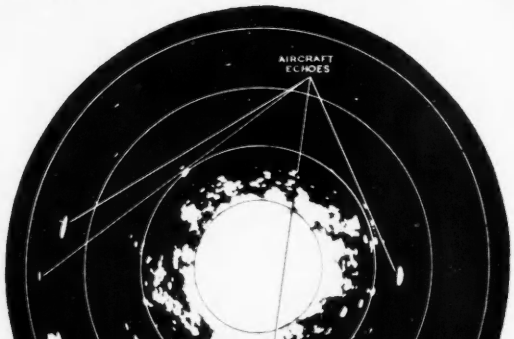


FIG. 1 (*above*). Illustrating effect of Permanent Echo Cancellation (M.T.1) on Radar Display. (Marconi Type S.232.)
The left screen shows M.T.1 on and the right M.T.1 off.

FIG. 2 (*left*). Pointer Display of Automatic V.H.F. Direction Finder. (Marconi Type AD210.)

system, is only intended to bring the pilot down to a point at which he can clearly see the runway for landing; neither are used as true "blind landing" systems for civil aircraft.

Even when the pilot has actually landed, he will still be given electronic assistance. He will receive taxying and marshalling instructions from Ground Movement Control by radio, and his progress may be watched on a short range, highly accurate radar which shows the controller a clear picture of the runways, perimeter tracks and buildings, in addition to parked and moving aircraft, vehicles, and sometimes even pedestrians. To attain this clarity of detail, the radar operates on a wavelength of about eight millimetres, and in poor visibility conditions can be extremely valuable. (See Cover, Inset.)

Most of the terminal facilities mentioned in the previous paragraphs would be used for long-distance flights as well as for the medium-distance taken as an example, but somewhat different conditions would have been encountered along the route in the case of a North Atlantic flight, such as is undertaken nightly by many aircraft. A typical non-stop flight would be about 2500–3000 miles and take about twelve to fifteen hours in the West-East direction. The requirements are basically the same as those already mentioned, but as there are no airways across the Atlantic, and conditions vary so much over such long distances, the necessity for good communications, both between air and ground, and between centres on the ground, is of paramount importance. It is not possible at present to communicate over the whole of

the Atlantic routes by VHF propagation, and therefore HF radio-telegraphy or radio-telephony is extensively used, the latter increasingly, as it offers the possibility of crew economies. Ground-to-ground communications are invariably by radio-teleprinter, as until the trans-Atlantic telephone cable or the new VHF Scatter techniques can be used, direct speech between controllers is not yet practicable across the Atlantic.

Navigation is carried out partly by the use of two further electronic aids, although astro-navigation is also extensively practised. The first system, known as Consol, consists of a ground transmitter, operating in the medium-frequency band, and the signals from it can be heard on the normal aircraft-receiver, as used for beacons. A number of dots are heard which merge into dashes, and the relative number of dots and dashes heard can be interpreted as a bearing from the transmitter, using the appropriate charts.

The other system, known as Loran, consists of pairs of pulsed ground transmitters operating in the Medium or High-Frequency bands. The pulses are observed on a cathode-ray tube in the aircraft, and from the relative positions of the pulses, position lines, and eventually fixes, can be determined from charts.

FUTURE OF CIVIL AVIATION COMMUNICATIONS

As more aircraft fill the skies, their speeds approaching that of sound, and their operating heights increasing to 40,000 feet and above, deficiencies in the communications and navigational aids will become apparent, and, in fact, they are doing so now. When Comet aircraft were in regular service it became difficult to guarantee that the information required along the route concerning the progress of the aircraft would arrive in time to be of use. To overcome this difficulty it will be necessary not only to use teleprinter operation throughout and to improve radio-teleprinter operation, but completely to mechanise the handling of the messages within the many relay and terminal stations. Luckily, suitable techniques, including temporary storage, are becoming available, and the chief difficulties are those associated with finance and the necessity to obtain international agreement.

Communications between air and ground also become more difficult as traffic grows. More and more frequency channels are required in the Very-High-Frequency band, and as aircraft fly higher they are able to make more use of VHF. At the same time, this also increases the possibilities of interference, and stations a few hundred miles apart which could at one time use a common frequency within their respective areas, now find that aircraft above, say, 30,000 feet will hear both stations at the same time. The answer is to narrow the frequency spacing between the channels available, and whereas the present frequency spectrum has been channelled on the basis of a 200 kilocycles-per-second band-width, giving only 70 channels to civil aviation, airborne equipments are now being produced which have a spacing of only 50 kilocycles per second, thus allowing 280 channels for the future. The lower limit in band-width has not yet been reached, as ground equipment has been produced which, it is claimed, can operate successfully on band-widths of 25 kilocycles per second.

On the High-Frequency side, more channels and greater efficiency can be obtained by the use of Single Sideband operation, in which the carrier is wholly or partly suppressed, together with one sideband. This is already successfully operated on ground-to-ground circuits, but if the carrier is completely suppressed it becomes necessary to re-insert it in the aircraft receiver, and this calls for an oscillator of very high stability. A start has also been made on ground-to-air teleprinter systems, and on selective calling of aircraft by push-buttons. Trials of the former are in progress on the North Atlantic route, and we may expect to see both these systems extended in the future.

Improved navigational aids will be necessary to assist jet aircraft to fix their positions more accurately, and this may call for Distance Measuring Equipment (DME), either of the form already standardised but not commonly used, or in some new form, such as is provided in the U.S. common civil and military system known as TACAN. The more effective operation of Air Traffic Control will require that aircraft shall be able to fly given paths more accurately, and unless Decca be adopted, this will call for an increase in accuracy of VOR.

While basic ground radar systems may not materially

FIG. 3. Scanning Head for 10 cm. Surveillance Radar. (Cossor ACR Mark VI)

FIG. 4. Civil Aeronautics Administration's Air Route Traffic Control Centre, New York's International Airport (Idlewild). The long-range control of aircraft, now possible in the New York Metropolitan Area, is due to thirteen General Electric radar scopes, presenting a picture of all aircraft within a radius of over 100 miles, and located in the new Air Route Traffic Control Centre.

change in the near future, we can expect radical changes in the methods of display, coupled with the use of new systems of handling the mass of radar and other data required for the efficient exercise of Air Traffic Control. If aircraft will carry a small additional radar responder, and thus become co-operative targets, ground radars can provide much more solid cover, and information could be sent back from the aircraft to the ground, by suitable coding of the airborne radar.

An integrated radar-computor system developed in the U.S.A. is known as "Volscan". It is claimed that this system will automatically track aircraft targets appearing on a radar tube, and compute the necessary heading and altitude for each aircraft to make good a scheduled arrival time.

It is often an advantage to site a radar station some considerable distance from the Air Traffic Control Centre that it serves. Until recently, it has not been possible to remote the radar picture, but this has now been accomplished by the use of a microwave radio link.

The problems of long-range navigation, as mentioned in connexion with the North Atlantic, are likely to be solved either by the adoption of one of the promising new aids, such as DECTRA, or NAVARHO, or by the development of self-contained aids carried in the aircraft.

DECTRA and NAVARHO are both low frequency aids between 50 and 100 kilocycles, the first being an adaptation of the Decca system, which, by the use of stations on either side of the Atlantic, can provide track guidance with an indication also of distance travelled, and can present both kinds of information in a pictorial display to the pilot. NAVARHO provides all-round bearing and distance from a single station, the presentation being on meters.

In self-contained airborne aids, changes in acceleration or velocity are measured either by inertia effects or by application of Doppler principles, and these changes are integrated into changes of distance or bearing. It is, of course, necessary to know the position of the aircraft when the computor begins to function, or to be able to feed in corrections to position should the equipment mal-function.

The above gives some indication of the extent to which electronics assists air navigation and communication. Other applications to aviation may be found in meteorology.

POLARISED LIGHT AND ANIMALS

J. D. CARTHY, M.A., Ph.D.

Queen Mary College, Mile End Road, London

Man has navigated by the sun since he developed reliable chronometers. Unlike many natural landmarks the sun is constant, unaffected by storm or earthquake. At any one time of day and year it will be at one particular place in the sky. It has the further advantage as a guide in being unique; many landmarks are deceptively like one another. Its sole disadvantage is that even a small amount of cloud in the sky may hide the sun's exact position and make this means of navigation impossible. Nevertheless it is not surprising that many animals can use the sun as a guide in finding their way about.

The rays of the sun are scattered by the molecules of the atmosphere, the light becoming polarised at least in part. This produces a pattern of polarised light over the sky which bears a constant relationship to the sun (Fig. 1). If only a small part of this pattern can be detected, the position of the sun itself can be deduced. Light at the zenith is most strongly polarised at sunrise and sunset; at these times some people can see an optical effect in the sky directly above them caused by the polarised light (Haidinger's fringes), but apart from this we have no sensitivity to the pattern, nor apparently have any other vertebrates. But it is now clear that a number of arthropods do make use of the polarised light pattern in finding their way about.

KEEPING A STRAIGHT PATH

Navigation in its simplest form consists in using beacons or landmarks to correct a possibly erratic course and maintain a straight one. The sky pattern can be used for this. The larvae of a sawfly, *Neodiprion banksianae,* move along a straight path beneath a polaroid screen, but as soon as the pattern is changed by rotating the screen, the larvae turn through the same angle and crawl in the new direction. Some moth caterpillars will also use this light pattern, but they are less dependent upon it, and the sun itself takes precedence, for they will orientate to the sun if it is visible, ignoring any pattern formed artificially with a polaroid screen. When smoke or clouds made up of ice crystals drift across the sky, new polarised light patterns are set up and then the larvae orientate to these. Here there is no navigation to a definite goal, and therefore the relation of the polarised light pattern to the fixed point of the sun does not matter. The larvae are simply using the guide as a method of organising their wandering into straight lines, by which they will in all probability encounter better environmental conditions quicker than if they wandered erratically, circling and looping over the same ground.

SANDHOPPERS

However, some animals, if they are displaced from habitats where conditions are particularly good, need to move back to them. Pardi and his co-workers have shown that this is in fact what *Talitrus saltator,* the sandhopper of the seashore (Fig. 2), does. These amphipod crustaceans live on moist sand near the water's edge; if they are taken away and put on dry sand higher up the beach, they head seawards to regain their former position. Sandhoppers from the west coast of Italy, by the Tyrrhenian Sea, were transported to the east coast on the Adriatic seaboard. When placed on the dry upper shore, they moved up the shore in the direction which in their usual surroundings would have led them seawards. A polaroid filter held over them will disorientate them if the pattern of the sky's polarised light is disturbed. But of course the sun moves during the day, and clearly a pattern which will direct the animals seawards when its image is held in certain ommatidia of an eye at one time, will not do so at any other time, as it will have changed its position in the sky. So, unlike the sawfly caterpillars—which were not heading for any particular place—the sandhoppers must make allowance for the diurnal movement of the sun if their navigation is to be even roughly accurate. In fact when these animals were kept under artificial light which gave a dark/light sequence twelve hours out of phase with night and day outside, they were almost exactly 180° out in their navigation (Fig. 3), an error which would be expected if they were interpreting the light pattern on a basis of its expected position

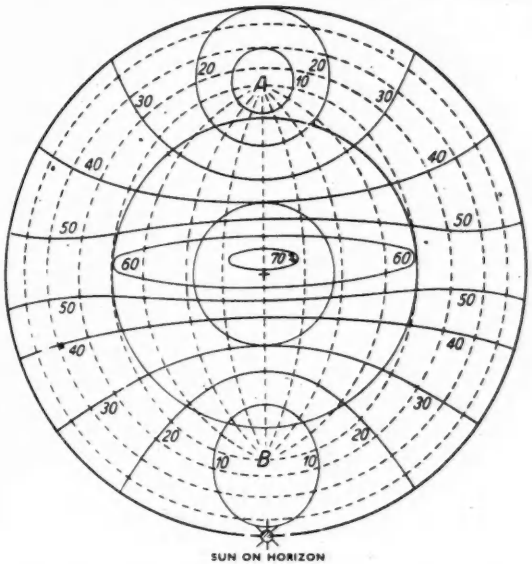


FIG. 1. Pattern of polarised light over the sky when the sun is on the horizon. The cross marks the point directly over the observer's head. (*From Muller-Pouillet, "Lehrbuch der Physik".*)

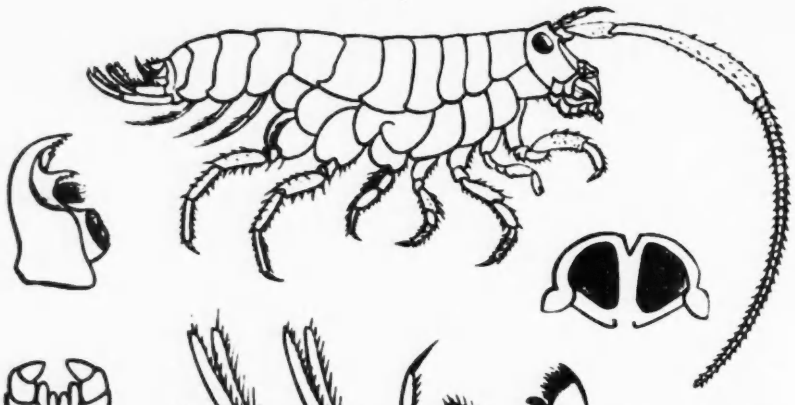


FIG. 2. *Talitrus saltator*, the sandhopper. (*From Bate and Westwood's British Sessile-eyed Crustacea, 1863.*)

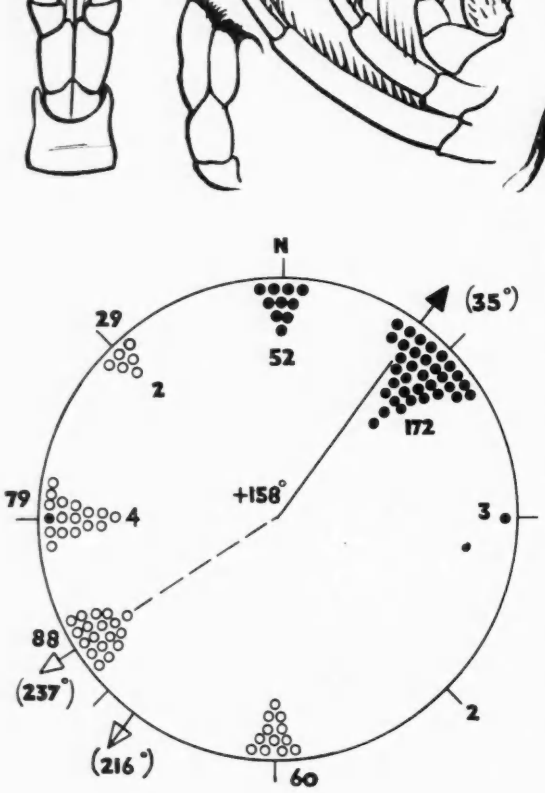


FIG. 3. Sandhoppers which had been kept in artificial "day night" conditions twelve hours out of step with the real day night (●) moved in a different direction to hoppers which had not been subjected to this treatment (o). The actual bearing of the shortest distance to the sea was 216. The figures within the circle represent the numbers of experimental animals and those outside the control animals, each ● or o being equivalent to 5 observations. (*From Carthy, after Pardi and Grassi.*)

in the wrong half of the day, their time sense having been thrown out of gear by the artificial day and night sequence. The timing mechanism would not have to be very accurate, as the sea to which they head usually presents a wide front, any part of which is equally favourable. But even this poses a number of interesting problems, such as whether the animals learn the correct direction or whether the navigation is innate; also how adaptable this learning is (if learning it is) when a sandhopper is swept away from its usual beach, to the opposite shore of a small bay, for example. From what is known at present, it appears that each population is adapted to move in the correct direction for the particular place in which it is found.

THE DANCE OF THE HONEYBEES

The return of social insects to their colony demands an accurate system of navigation, for here the goal is small by comparison with the sea's edge to which the sandhoppers go. Von Frisch demonstrated the remarkable fact that honeybees, which home most accurately, may do so by means of the polarised light pattern from the sky. Von Frisch's experiments, which are well known, show that polarised light pattern influences the direction of the dances performed by successful foragers on their return to the hive—dances which indicate to other foragers the direction and distance of the source of food which the scout bee has found. The direction is indicated as a bearing from the sun, whose position is represented in the dance by the vertical up the face of the comb. Yet there must be many occasions in which the sun itself is not visible either to the successful scout

or to the forager leaving the hive after having learned from the other bee's dance the direction in which to fly. At these times the feat of transformation must be quite remarkable; from the patterns she can see the scout must derive the corresponding position of the unseen sun, so that she may orientate her dance correctly. In turn the forager which receives the information—not in visual, but kinaesthetic terms, by the way—has to translate the position of the sun it cannot see but which has been indicated in the dance, into the correct pattern of light which it must receive in its ommatidia to maintain a course at the correct angle to the invisible sun. This is complex enough at our human level and no little intellectual feat, yet it is carried out quite automatically within the nervous system of the bee. Add to this the fact that bees make allowance for the movement of the sun by using a time sense—as they must to navigate accurately—and the complexity of their behaviour becomes almost bewildering. Kalmus has shown recently that northern hemisphere bees taken to Brazil some 425 years ago have given rise to local races whose habits have changed from those of their ancestors, so that they are capable of compensating for the sun's *anti*-clockwise movement in the southern hemisphere.

NAVIGATING ANTS

Though nothing comparable to this transfer of information has been found among the ants, some species of this other big group of social insects do use polarised light for navigation. Black garden ants (*Lasius niger*) permitted to run to the centre of an arena to retrieve larvae will quickly settle down to entering and leaving by the most direct path. But their ability to find their way can be disturbed by various methods. If a polarised light source is used to illuminate the arena, this can be done by altering the direction of the plane of polarisation. The disturbance is greater as the filter is rotated through one right angle, and sometimes the alteration in direction of the homeward path seems to be identical with the change of the polarisation plane. This relationship is even more marked in the red ant (*Myrmica ruginodis*). With these ants, Vowles found a strong correlation between the change of plane and their consequent change of direction (Fig. 4). Both these series of experiments were carried out in the laboratory, the light source illuminating the ants from above, so that

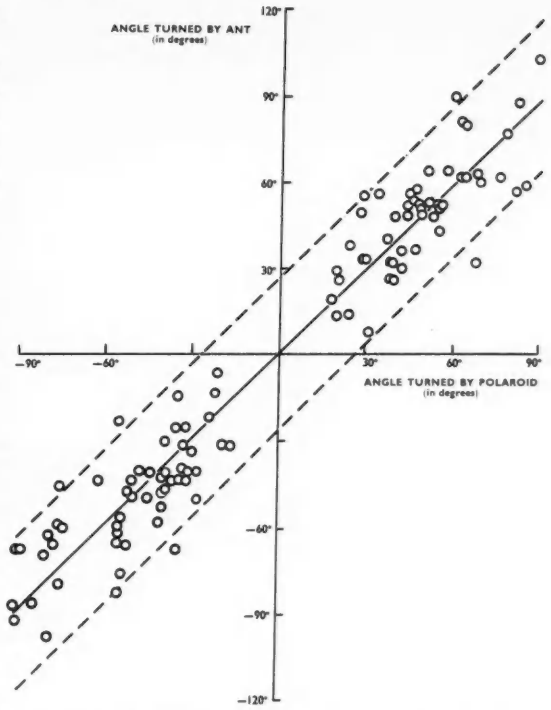


FIG. 4. Graph of relationship between change of direction of the ant and the change of plane of polarisation. (*From Vowles.*)

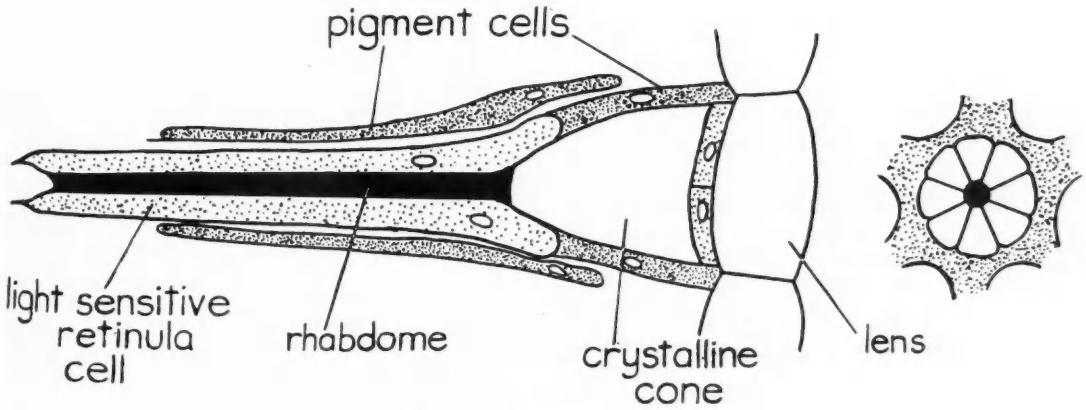


FIG. 5. The ommatidium of the compound eye of an insect to show the relation of the retinulae and the rhabdome.

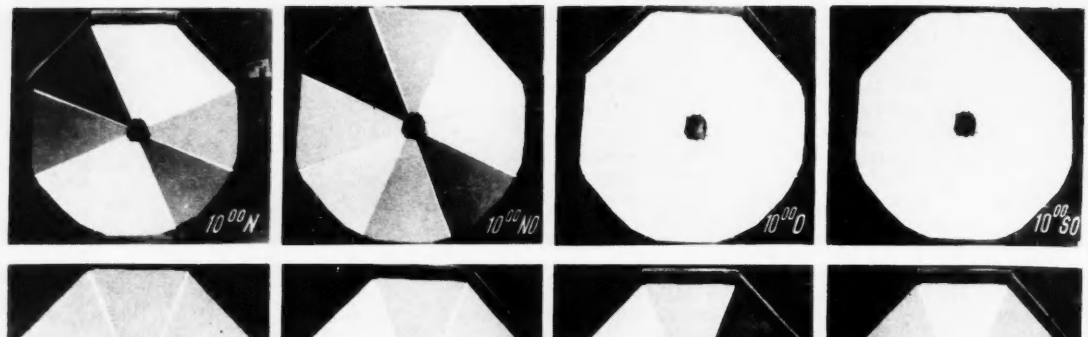


FIG. 6. Patterns in von Frisch's octagon when viewing the sky in different directions at the same time of day. *Top row, left to right:* north, northeast, east, southeast. *Bottom row, left to right:* south, southwest, west, northwest. (*Reproduced by courtesy of Professor K. von Frisch.*)

there was no need to suppose that they were using as complex a pattern as that perceived by honeybees. Nevertheless, ants are capable of navigating by means of the sky pattern in nature; for, if a polaroid filter held over them is rotated, they often change their direction or become completely confused. This explains the observations, baffling at the time, made by Santschi on North African ants. He noticed that they were able to maintain their direction if the sun were screened, but with parts of the sky remaining visible to the ants. He suggested then that the ants could see the stars by day; now it is clear that they were using the polarised light pattern.

THE MECHANISM IN THE EYE

It is not possible to be absolutely certain of the position of the analyser in the compound eye of an ant or bee. To judge from Autrum and Stumpf's electrophysiological investigation of the activities set up by polarised light in the eye, it is somewhere within each ommatidium (Fig. 5). Von Frisch constructed an octagon of polaroid sheet, in which he saw different patterns when he viewed various parts of the sky at any one time (Fig. 6). He also confused dancing bees by holding a polaroid filter over them; he then found, on looking at the sky through the polaroid, as one of the dancing bees would, that the pattern in his octagon existed nowhere in the sky at that time. This implies that the bees were confused by an unnatural pattern which it was impossible for them to interpret. The rhabdome lies between eight retinulae cells in the honeybee, and is secreted by them as an eight-part structure; von Frisch's experiment with the octagon may possibly thus indicate that the rhabdome is the structure responsible for the analysis. There is other evidence that in Diptera the rhabdome may act as an analyser. It is well suited to do so, since each segment is composed of orientated molecules; such a birefringent arrangement would refract more or less light into the sensitive cell according to the plane of polarisation of that incident light.

KING CRABS

Laboratory experiments have shown that a number of other arthropods are able to detect a change in plane of polarisation. Usually it is very difficult even to guess at what part this ability plays in the animal's behaviour in nature. It is difficult to imagine, for example, what use the King Crab's sensitivity to polarised light can be. Animals which react to changes in plane or polarisation in the laboratory may not be sensitive to the plane of polarisation itself, but to changes in the intensity of the light entering their eyes, this being brought about by changes in the plane of polarisation which have occurred for purely physical reasons. The amount of light passing in, as opposed to that which is reflected from the surface of the lens, will be dependent at large angles of incidence not only on the angle of incidence but also on the plane of polarisation; the differences between rays of different planes is almost negligible at small angles of incidence. That is, the closer to the optical axis of an eye the ray strikes, the smaller will be the effect of changing the plane of polarisation. Now the electrical responses in the optic nerve of the King Crab show little variation when an ommatidium is illuminated by rays at different planes of polarisation parallel or close to the optical axis of the ommatidium, while at larger angles differences become apparent. It is not necessary to postulate an analyser to explain these phenomena.

FRUIT FLIES AND WATER FLEAS

The fruit fly, *Drosophila*, will react to polarised light; but it seems almost certain that, for the physical reason given above, its reaction is really to differences in the illumination of the eye at different planes of polarisation. The flies then only show their phototactic responses which they give in any light gradient. And a similar explanation will probably account for the responses of *Daphnia* and a number of other Cladocera which have been tested, though in this case we can make a guess at a possible use of such behaviour. These freshwater animals feed on algae and diatoms. Their food will therefore be more plentiful in the well lit parts of the pond. A response to polarised light may thus have the function of bringing the animals out from the shade of water plants into the light where the algae are plentiful.

POLARISED LIGHT UNDER WATER

Recently it was shown that there is a constant pattern of polarised light under water, as constant as that in the sky, and this may help to explain some of the diurnal movements of planktonic organisms. By looking upward through clear water off Bermuda, Waterman found that he could detect the sky pattern unchanged within a cone of 96° centred on the zenith; but outside this, at all angles down to the horizontal, there was a different but fixed pattern. This pattern, and that seen by looking down at any angle between the horizontal and the nadir, is caused by the scattering of the light by particles in the water, the light being polarised nearly everywhere at right angles to the direction of its rays. The percentage polarisation also varies. It might be, as Waterman suggests, that some of the planktonic organisms which regularly move nearer the surface during the forenoon, to sink and spread downwards after midday, are reacting to changes in the polarised light pattern; even on cloudy days it will show its changes and indicate the sun's movement.

Land- and water-dwelling arthropods alike seem to be guided by this light pattern. The patches of blue sky can certainly be used as a guide on cloudy days when the sun itself, the main navigational reference point, is hidden; even when the sky is completely overcast, the light pattern may be sufficient guide.

REFERENCES

Autrum, H., and Stumpf, H., "Das Bienenauge als Analysator für polarisiertes Licht", *Z. Naturf.*, 1950, vol. 5b, pp. 116–22.

Baylor, E. R., and Smith, F. E., "The orientation of Cladocera to polarised light", *Amer. Nat.*, 1953, vol. 87, pp. 97–101.

Carthy, J. D., "The orientation of two allied species of British ant", *Behaviour*, 1951, vol. 3, pp. 275–318.

Fernández-Moran, H., "Fine structure of the insect retinula as revealed by electron microscopy", *Nature*, 1956, vol. 177, pp. 742–3.

Von Frisch, K., "The dancing bees", Methuen, 1954.

Kalmus, H., "Sun navigation of *Apis mellifica* L. in the Southern hemisphere", *J. exp. Biol.*, 1956, vol. 33, pp. 554–65.

Menzer, G., and Stockhammer, K., "Zur Polarisationsoptik der Facettenaugen von Insekten", *Naturwissenschaften*, 1951, vol. 38, p. 190.

Pardi, L., and Papi, F., "Die Sonne als Compass bei *Talitrus saltator Montague*", *Naturwissenschaften*, 1952, vol. 39, pp. 262–3.

Pardi, L., and Grassi, M., "Experimental modification of direction finding in *Talitrus saltator* and *Talorchestia deshayei*", *Experientia*, 1955, vol. 11, p. 202.

Stephens, G. C., Fingerman, M., and Brown, F. A., Jr., "The orientation of *Drosophila* to plane polarised light", *Ann. ent. Soc. Amer.*, 1953, vol. 46, pp. 757–93.

Vowles, D. M., "Sensitivity of ants to polarised light", *Nature*, 1950, vol. 165, p. 282.

Waterman, T. H., "Polarised light and angle of stimulus incidence in the compound eye of *Limulus*", *Proc. nat. Acad. Sci. Wash.*, 1954, vol. 40, pp. 258–62; "Polarisation patterns in submarine illumination", *Science*, 1954, vol. 120, pp. 927–32.

Wellington, W. G., Sullivan, C. R., and Green, G. W., "Polarised light and body temperature level as orientation factors in the light reactions of some hymenopterous and lepidopterous larvae", *Canad. J. Zool.*, 1951, vol. 29, pp. 339–51.

TWENTY-FIVE YEARS AGO

THE INTERNATIONAL MAP

From DISCOVERY, 1932, vol. XIII, p. 91

In our March issue for 1932 Basil D. Nicholson, Assistant Surveyor, Oxford University Greenland Expedition, published an article on "The International Map of the World".

"Since cartography", he said, "is the most obviously international activity of the modern state it was inevitable that the idea of an international map of the world should attract support long before the idea of a corporate world had gained popularity."

We are still far from the "corporate world", but, as the author went on to tell us, "The *Carte du Monde au Millionième* . . . was first proposed by Prof. A. Penck at the Geographical Congress in Rome in 1891, and gained approval rather than support. . . . A long series of conventionally impotent committees reported to geographical congresses in 1895 (London), 1899 (Berlin), 1904 (Washington), and 1908 (Geneva), and their remarks are still to be found in the appropriate pigeonholes by anyone morbid enough to look for them. . . . At the 1908 conference, when the United States proposed standardisation and the definition of the rules on which the maps were to be compiled, our own general staff began to take a decisive interest in the International Map. The map was effectively agreed on at a conference held in 1909 at the British Foreign Office, but work on it remained provisional till the 1913 conference . . . at Paris."

"The advantages of a complete, published, international map on an adequate scale, standardised in its conventional signs and printed on common sheetlines, are scarcely possible to exaggerate. Once it became generally known, the natural demand would make its sheets available, as a matter of course, in at least the capital cities of the world. But the prospects of its early completion are poor. In a world whose motorships buffet their way round the Horn because their dwindling cargoes will not pay the dues of Panama, whose luxurious apparatus stands unused, as though the Waldorf-Astoria had been built in Connemara, it is not likely that this half-completed venture will fare better than others. It will remain . . . an uncompleted framework in a world that cannot even pay the running costs on its existing equipment. . . ."

ANTIGEN-ANTIBODY COMPLEXES

THE ELECTRON MICROSCOPE AS A VISUAL AID TO CHEMISTRY

G. C. EASTY, Ph.D., and E. H. MERCER, Ph.D.

Chester Beatty Research Institute, London

When a foreign substance is injected into an animal it will stimulate, if it possesses suitable properties, the appearance of antibodies in the blood of the animal. The most striking property of an antibody is its ability to combine specifically with the injected substance, the antigen. This reaction is one of the protective mechanisms evolved by living organisms in their fight against disease. It is the basis of one form of immunity.

A number of theories have been put forward to account for the mechanism of this precipitation reaction, of which the most strongly supported is the Marrack-Heidelberger lattice theory. This theory postulates that the antigen molecule possesses two or more groups capable of reacting with complementary groups on the antibody molecule. The antigen and antibody are considered to form small aggregates of three or four molecules, which continue to react forming a three-dimensional lattice of approximately alternating molecules of antigen and antibody. If sufficiently large, this aggregate will form an insoluble precipitate.

Direct proof of the formation of such a lattice, such as might be provided by electron microscopic examination of these precipitates, has been lacking until now. For although electron microscopes exist which might be capable of resolving the molecules of antigen and antibody, the two types of molecules are indistinguishable because they have the same density in the electron microscope.

To some extent this has been overcome by forming antibodies to such large characteristic particles as those of the rod-like particles of tobacco mosaic virus. A much more satisfactory approach is to use a protein molecule of characteristic appearance in the electron microscope. Of these the most suitable is the protein *ferritin*, the molecules of which, as was shown by Farrant, carry with them their own *label* in the form of a dense core of iron.

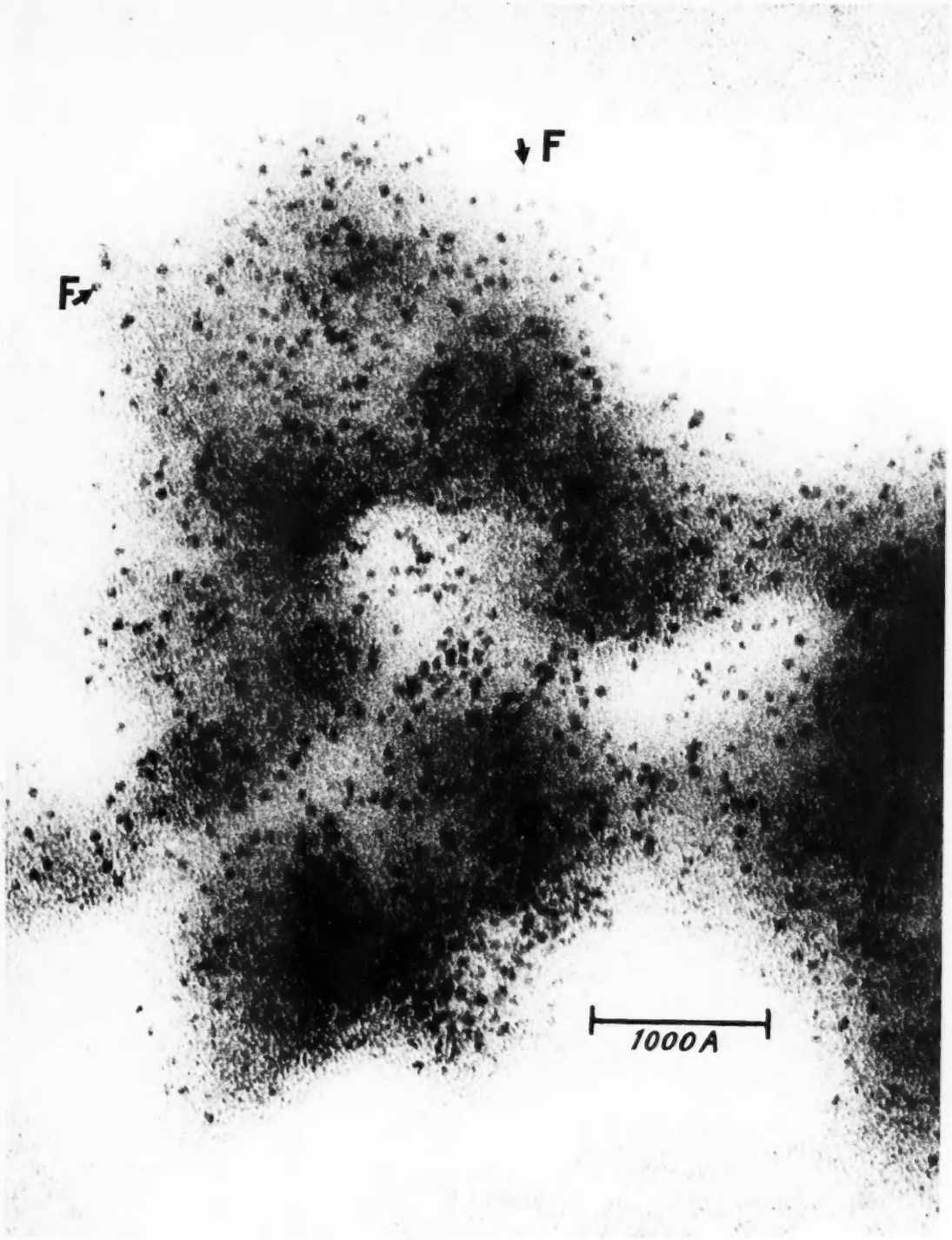
A preparation of crystalline ferritin, obtained from horse spleen, was injected into a rabbit and, after a suitable time to allow antibodies to form, the rabbit was bled and the blood allowed to clot. The fluid portion of the blood, the serum, was further fractionated with ammonium sulphate and the least soluble portion of the proteins of the serum, containing most of the antibody, was isolated.

Solutions of ferritin and the specific purified antibody were then mixed in varying proportions and the resulting aggregates and precipitates examined unde the electron microscope. Pictures reminiscent of frog-spawn (see Fig.) were obtained. The dark iron cores of the ferritin molecules show up clearly in the midst of the less dense mass of antibody. This picture is much as we would expect on the basis of the Marrack-Heidelberger theory, although the intermolecular spacings are hardly as regular as might be implied by the theory.

The ratio of antibody to antigen in a precipitate has been observed to vary considerably, but there are reasons for believing that, when the antibody is in excess, the antibody molecules will project from the surface of the antigen molecule and react with a second antigen molecule giving a separation between the antigen molecules equal to that of the length of the antibody molecules, that is 250 to 400Å. Distances of about this order are common in electron micrographs of the aggregate complex.

There are other regions where the distances separating the ferritin molecules are greater than 400Å. These gaps may be caused by the unavoidable contamination of the ferritin with apoferritin, that is to say ferriti which has lost its iron but which retains the property reacting with the antibodies. That the ferritin is co taminated with other substances is shown by the "ge diffusion test". In this test the antigen and antibody solutions are allowed to diffuse towards one another through a gel. Each antigen combines with its specific antibody forming under suitable conditions a band of precipitate. If more than one band is obtained, then more than one antigen and antibody system was present. Several bands were obtained with the ferritin system, indicating contamination of the ferritin, probably mainly with apoferritin.

These observations appear to support the lattice theory of the structure of antigen-antibody complexes and are an example of the emerging use of the electron microscope as a visual aid to chemistry.


F
F
1000 A

MICROSCOPICAL EXAMINATION OF METALLIC SURFACES

J. NUTTING, Ph.D., B.Sc., M.A.

Department of Metallurgy, University of Cambridge

The first published account of a systematic survey with the aid of a microscope appeared in the middle of the 17th century, and since that time the microscope has proved one of the most valuable weapons in the armoury of the scientist. However, a further two hundred years were to elapse before the microscope was used successfully for examining metals. In 1864 H. C. Sorby overcame the chief difficulty—the preparation of the metal surface. During the next twenty years Sorby improved his methods, and in 1887 he published an important paper in the history of metallurgy; it described the results of his researches.

Earlier workers had tried to examine metals with the microscope. Their methods involved breaking the metal with a hammer blow and then looking at the fracture surfaces. But as these are rough and the depth of focus of the microscope small, satisfactory images could not be obtained and little progress was made. Sorby's earlier interests were in the field of geology where he made outstanding contributions to our knowledge of the mode of deposition of sedimentary rocks, and during these studies he perfected methods of examining rock surfaces. Later he applied these same methods to the examination of meteorites, and then to iron and steel, thinking that it might help him to understand the origin of meteorites. He was, however, quick to realise the metallurgical importance of his findings.

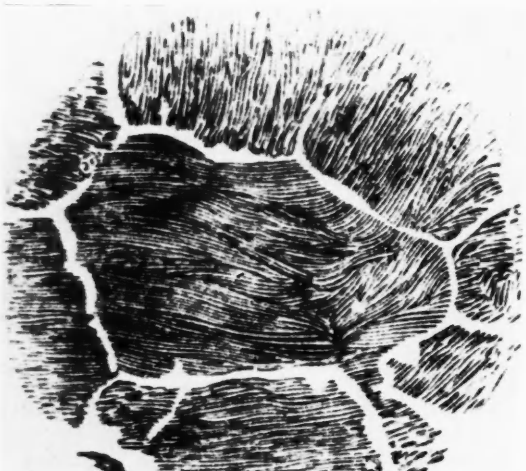


FIG. 1. Sketch of Pearlite by Sorby (1886).

Sorby's skill lay not only in the preparation of specimens but in his ability to interpret his observations correctly. An example of one of his drawings, which dates from 1886 and which shows the structure of 0·7% carbon steel, is given in Fig. 1. The light areas are of ferrite (pure iron) and the central and outer regions show alternate lamellae of ferrite and iron carbide (Fe_3C). This structure has since been named pearlite, since it has an iridescent appearance when viewed with the naked eye. Sorby was the first to observe this lamellar structure in steel, and he concluded that the carbon was present as a compound of iron and carbon; but he did not determine the composition of the iron carbide.

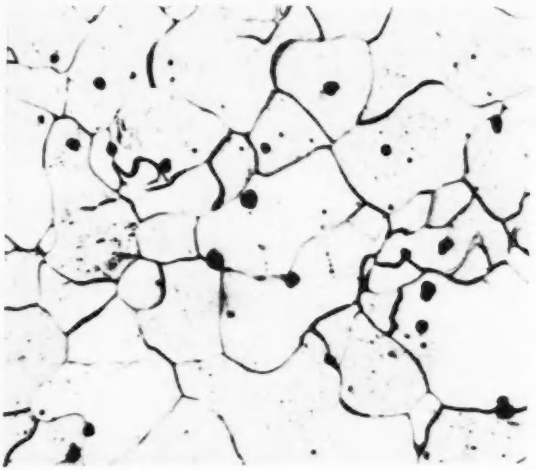
PREPARING A METAL FOR EXAMINATION

The method developed by Sorby for preparing a metal for examination with the microscope is, with slight modifications, still the one most widely used today. The surface to be examined is rubbed on progressively finer grades of emery paper, and is then polished by holding it against a rotating wheel covered with cloth on which an abrasive powder is sprinkled. (Sorby used a cloth-covered board and moved the specimen to and fro by hand.) During polishing heat is generated, and modern research has shown that the friction between the particles of the abrasive and the asperities on the metal cause the surface layer to melt, flow, and resolidify, so leaving a bright mirror surface. This surface is not truly representative of the metal, and to make the underlying structure visible the flowed layer has to be removed by etching, usually with a dilute acid.

The microscope is then used for examining the etched metal surface, which is illuminated by adopting a device developed by Beck. A horizontal beam of light is directed through an aperture in the microscope tube, where it strikes a glass plate inclined at an angle of 45°. About 10% of the light is reflected down through the objective lens, where it strikes the metal surface and may be reflected back through the objective lens. Of the returning light, 90% will pass through the glass plate to form the primary image, which is then magnified further with the eyepiece.

THE POLYGONAL NETWORK OF A METAL

On examining the polished and etched surface of a pure metal or a simple alloy, a polygonal network is observed of which an example is shown in Fig. 2. From such a structure it is deduced that a metal consists of an arrangement of crystals fitting together as shown in the sketch, Fig. 3. In preparing the metal surface a section through the grains is taken, and on etching with a dilute acid the boundary regions of the grains are



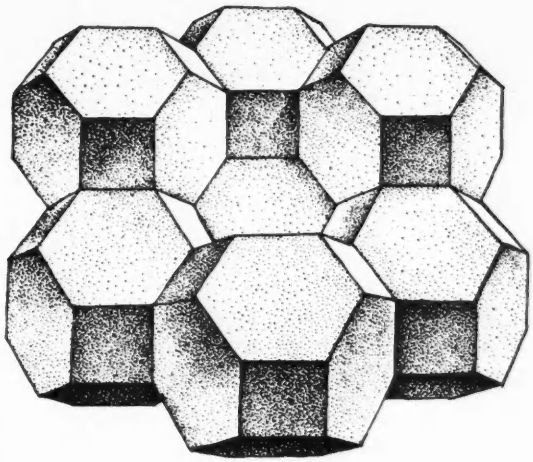
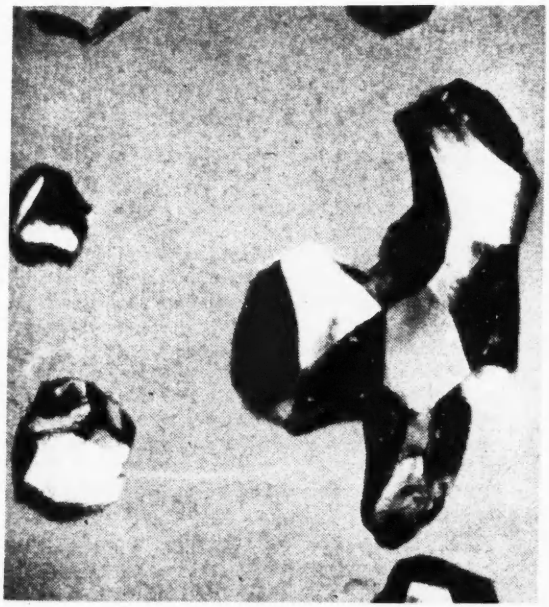


FIG. 2 (*left*). Photomicrograph of pure iron polished and lightly etched to show polygonal grain structure. Magnification, ×100. FIG. 3 (*right*). Idealised drawing of the grain structure of a pure metal.



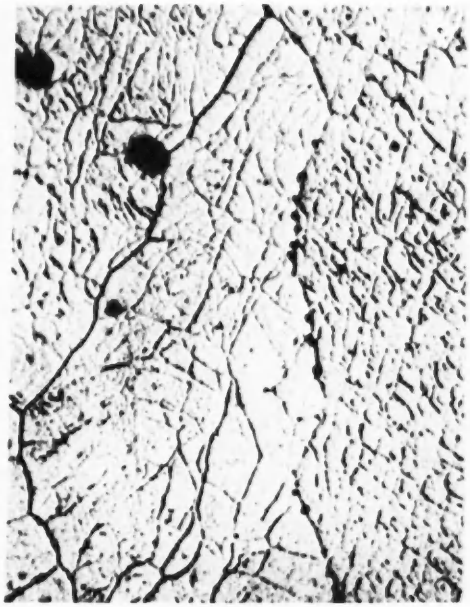


FIG. 4 (*left*). Separated grains of an α brass. Magnification, ×50. FIG. 5 (*right*). Photomicrograph of pure iron heavily etched to show sub-grains within a larger grain. Magnification, ×1,200.

preferentially attacked. Under the microscope the boundaries appear therefore as dark lines fitting together to give the structure shown in Fig. 2. An ideal state of affairs is represented in Fig. 3; each of the grains is of uniform size and of a uniform shape called a tetrakaidecahedron. This is one of the few regular solid shapes that can be used for completely filling space. By thermal and mechanical treatments it is sometimes possible to make a metal come apart around the boundaries of the grains. A photomicrograph of the separated grains of *a* brass (70% Cu–30% Zn) is shown in Fig. 4, where it can be seen that the grains are far from uniform in shape although they tend towards the ideal. It is thought that the reason for the shape of the metal grains is that forces are acting at their surface which tend to reduce the surface area to a minimum.

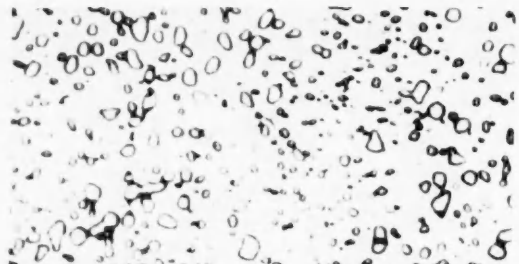


FIG. 6. Photomicrograph of sorbite showing roughly spherical particles of cementite in a matrix of ferrite (pure iron). Magnification, ×2,000.

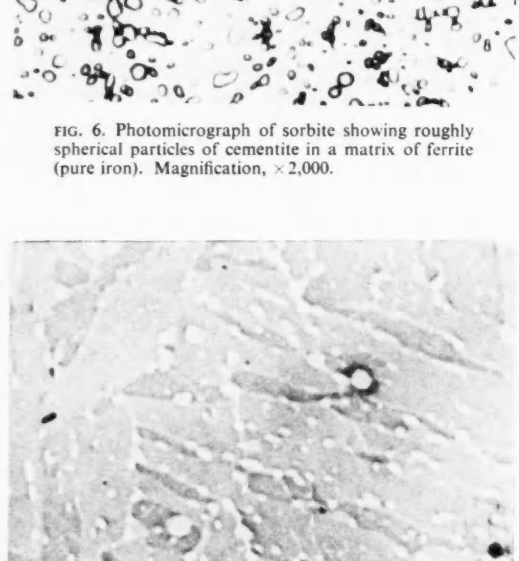


FIG. 8. Electron micrograph of a plastic replica from sorbite. The particles of cementite (light areas) are at the boundaries of the ferrite grains (dark areas). Magnification, ×5,000.

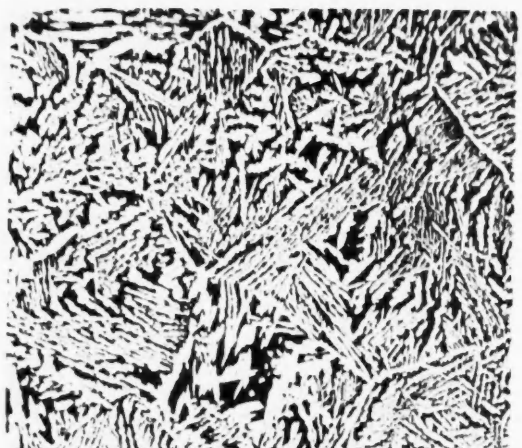


FIG. 7. Photomicrograph of an α–β brass (60% Cu–40% Zn). The α-phase is white and is present as grain boundary films and as needle-shaped particles within the grains of the β-phase. Magnification, ×120.

It can easily be proved that a tetrakaidecahedron has the minimum surface area to volume ratio of any of the solid figures which may be used for filling space completely.

It is possible to define a grain as a small single crystal which differs in orientation from its neighbours. However, within this single crystal, the arrangement of the atoms is not perfect and each crystal is sub-divided into smaller units or sub-grains which differ only very slightly in orientation from their neighbours. A photomicrograph of sub-grains within a larger grain is shown in Fig. 5.

PRIMARY AND SECONDARY PHASES

When alloying elements are added to a metal they tend to go into solid solution at first. The crystalline arrangement of the atoms remains the same, and the resulting microstructure is identical with that of a pure metal. With most mixtures of metals there is, however, a limit to the solubility of the alloying metal. If, by increasing the amount of the alloying metal, this solubility limit is exceeded, then some of the atoms of the two metals may come together in a new type of crystalline array—we say that a new phase has been produced. The first formed solid solution is called the primary phase, and the new crystalline array the secondary phase. Increasing the amount of the alloying

metal further will result in producing more and more of the secondary phase and less of the primary phase, until eventually only the secondary phase is present and once again the microstructure will be the same as that of a pure metal. Still further additions of the alloying metal may produce another phase and the sequence of changes will be repeated.

In a two-phase alloy the secondary phase may be present either within the grains or at the boundaries of the primary phase. At the boundary surfaces between the two phases, forces are acting similar to those at the boundaries of the primary phase grains. If the particles of the secondary phase are at the boundaries of the primary phase, then the shape of the particles will depend upon the relative magnitude of the forces at the interfaces between the primary and secondary phases. Thus in some cases films of the second phase around the grain boundaries of the primary phase are found, whilst in other cases the second phase forms as spheres. An example of the latter type of distribution is shown in Fig. 6. The specimen is a tempered steel, and the structure is called sorbite in honour of H. C. Sorby. Normally the grain boundaries of a metal are stronger than the grains, therefore when a metal breaks, the fracture path is through the grains rather than around the boundaries. If, however, a second phase is present as a grain boundary film, this may considerably weaken the boundary regions and failure will occur around the grains rather than through them.

If the particles of the second phase are formed within the grains of the primary phase, then usually the crystal orientation of the second phase relative to the primary phase is such that the distribution of atoms along the surface in contact is similar in the two phases. This type of interface has a low energy; it is therefore easy to produce and relatively stable. The resulting microstructure is shown in Fig. 7. The needle-like particles of the second phase are all inclined to each other at constant angles. These angles correspond to those found between the crystallographic planes (projected on to the plane of section) and along which the second phase has formed. This is called a Widmanstatten structure, after the name of its discoverer who first observed it in meteorites.

The mechanical properties of a metal are closely related to the microstructure. For example the strength of a metal increases linearly with the reciprocal of the square root of the grain diameter, and in two-phase alloys the strength increases almost linearly with the reciprocal of the spacing between the particles of the second phase. If detailed investigation of these relationships is to be made, then it becomes essential to be able to observe and measure structures where these features are very small.

OBSERVING FINE DETAIL

With the light microscope the ability to observe fine detail—i.e. the resolving power of the instrument—is limited by the wavelength of the light used. Assuming a wavelength of 5000 Å (1 Ångstrom unit $=10^{-8}$ centimetres), the resolving power of the best optical microscope is about 2000 Å. This means that any feature on the surface of the metal which has a size less than 2000 Å will, when viewed with the microscope, give an image of 2000 Å diameter. But if the light microscope is to be used for determining the grain size of metal, the grains will only be seen by the image from the etch pattern at the boundaries, and this pattern must be built up of image points each of 2000 Å diameter. In practice, therefore, it is difficult to see grains smaller than 10,000–20,000 Å. Thus a microscope with a much better resolving power is obviously needed.

The theoretical solution to this problem came in 1924

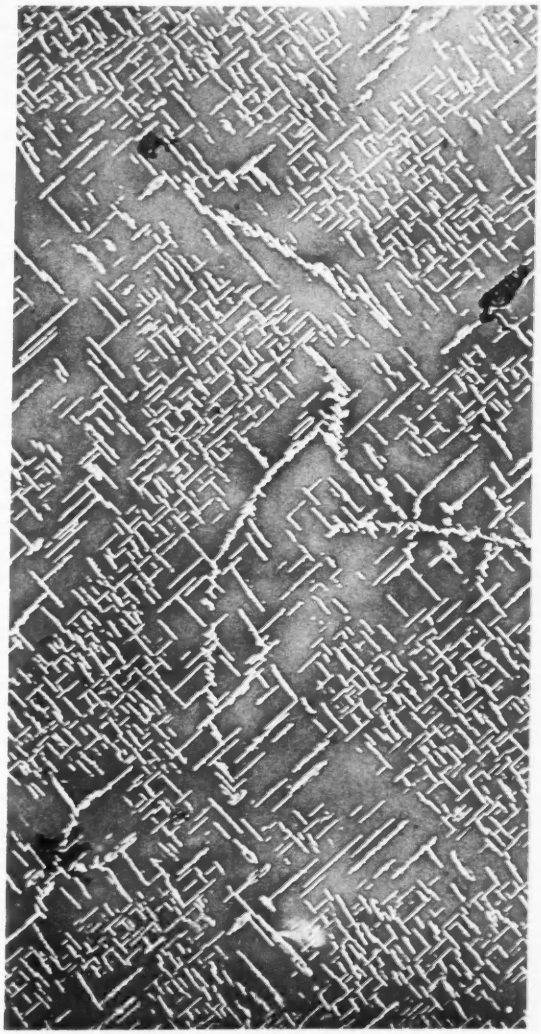


FIG. 9. Electron micrograph of an oxide replica from an aluminium-4% copper alloy. The light areas correspond to a precipitate of $CuAl_2$ within the matrix of aluminium. Magnification, × 15,000.

from De Broglie who postulated that an electron beam could be considered as having a wave motion of very short wavelength. The practical justification of this was provided in 1929 by Thompson, who succeeded in diffracting an electron beam, and by Knoll and Ruska who in 1931 produced the first electron microscope. Since that time there have been many improvements in the design and performance of electron microscopes, and instruments capable of resolving 10 Å are now commercially available.

THE ELECTRON MICROSCOPE

The conventional electron microscope is of the transmission type. An electron beam passes through the specimen to be examined and is then magnified by the objective and projector "lenses" to produce an image on a fluorescent screen. Contrast in the image results from differences in scattering power when the electron beam passes through the thick and thin parts of the specimen, or the parts having differences in atomic composition.

Metallurgists wishing to use the electron microscope to study the structure of metals were therefore confronted with a difficult problem. Metals readily absorb electrons, and it is very difficult to produce suitably thin films for examination by transmission. The problem was solved by the development of replica techniques. After polishing and etching a metal surface there are differences in surface height. An imprint of these may be obtained by adding a dilute solution of a plastic material in a volatile solvent to the metal surface. When the solvent evaporates a thin film of plastic is left, the upper surface of which is flat but the lower surface follows the contours of the etched metal. This film is now stripped from the metal on to a small copper grid and is then placed in the electron microscope. The contrast in the image is obtained by the differences in the scattering of the electrons as they pass through the thin and thick regions of the replica which correspond to the raised and lowered parts of the metal surface. An electron micrograph of a plastic replica from a steel is shown in Fig. 8. The light, roughly circular areas correspond to the iron carbide (Fe_3C) particles which are present at the boundaries of the ferrite grains. This structure may now be compared with the optical equivalent shown in Fig. 6.

ALUMINIUM

With aluminium and its alloys an alternative method of replica preparation may be used. This depends upon the fact that aluminium may be oxidised to produce a thin yet stable oxide film which can be easily stripped from the metal surface. The film so produced is of uniform thickness in a direction perpendicular to the free surface; thus if there are any changes in height on the metal surface the film will follow around these. When the film is stripped and put in the microscope the apparent thickness to the electron beam will be greater where there is a change in surface height. If there are alloying elements present in the aluminium resulting in the presence of a second phase, the new phase may not oxidise as readily as the aluminium and therefore the stripped film will be thinner over the particles of second phase. The size, shape, and distribution of the particles of this phase may therefore be inferred from an examination of the thinned regions, which will appear light in the electron microscope. An example of this type of structure is shown in Fig. 9. There are many interesting features in this electron micrograph.

The alloy is aluminium containing 4% copper which has been heated at 520°C for four hours, water quenched, and then reheated at 200°C for 100 hours. At room temperature copper is almost insoluble in aluminium but with increasing temperature the solubility increases and at 520°C over 4% of copper may be taken into solution. If an aluminium-4% copper alloy is water quenched from this temperature, then the copper will remain in supersaturated solid solution. Reheating for 100 hours at 200°C allows the excess copper above that soluble at 200°C to come out of solution when it forms the compound $CuAl_2$. The $CuAl_2$ precipitates from the supersaturated solid solution in the form of thin plates which on the section surface examined with the microscope will appear as needles, and, as can be seen in Fig. 9, these needles are inclined to each other at 90°. Aluminium has a cubic crystalline arrangement of its atoms and the plates of $CuAl_2$ form parallel to the cubic faces of these crystals. If the surface examined is also parallel to a cubic face of the crystal, then the $CuAl_2$ plates on the other cubic faces will, where they meet the plane of section, be inclined to each other at 90°.

STRENGTH OF METALS

If the crystalline arrangement of the atoms in a metal were perfect, then metals would be very much stronger than they are found to be. And in an aggregate of perfect crystals the grain boundaries would be a source of weakness rather than a source of strength as is generally the case. To account for the low strength of metals it is assumed that the crystal arrangements is not perfectly regular, but that there are regions of slight misfit called dislocations. When a new phase is forming in an alloy by precipitation from a supersaturated solid solution, then a dislocation, since it is a region of high energy, is a likely place for the new phase to grow. In Fig. 9 there are arrays of $CuAl_2$ plates which do not conform to the normal pattern. It is thought that these arrays represent the regions where precipitation has occurred on a dislocation. Until photographs of the type shown in Fig. 9 were obtained there was little visual evidence of the form of dislocations although much was known about their properties.

CARBON REPLICAS

With oxide replicas it is possible to reproduce detail of the order 50 Å whilst still retaining good contrast in the image; it is therefore unfortunate that the oxide technique may only be applied satisfactorily to aluminium and its alloys. Until recently all other metals and alloys were examined by taking plastic replicas, and

with these it is impossible to reproduce detail finer than 100–200 Å. The plastic material is composed of long molecular chains, and although these are capable of bending around the small structural features on the metal surface, when the plastic is put into the microscope and irradiated with electrons the molecular chains appear to straighten. They also combine with other chains, so producing much larger molecules which have a diameter of 100–200 Å, and it is these molecules which limit the resolving power. These difficulties have been overcome by the development of an entirely new technique: the direct carbon replica method. A carbon film about 50–100 Å thick is evaporated on to the metal surface. The film, being rather like the oxide film formed on aluminium and of uniform thickness in a direction perpendicular to the free surface, is then stripped by chemically attacking the underlying metal.

To deposit the carbon film, the metal specimen is first polished and etched, then placed in an evacuated chamber containing two pointed carbon rods held lightly in contact. On passing a current of about 50 ampères through the rods the tips become white hot and atoms of carbon evaporate from them to recondense upon the metal surface. The thickness of the deposited film depends upon the time allowed for evaporation of the carbon; suitable evaporating times are one to two seconds. The carbon replicas so produced give excellent contrast in the electron microscope; they are very stable and almost structureless, consequently resolving powers of better than 25 Å may be readily obtained.

A further modification of the carbon film method is to produce direct carbon extraction replicas. After depositing the film on to the surface of a two-phase alloy, the chemical stripping is carried out in such a way that only the primary phase is attacked. The replica comes away from the surface with particles of the secondary phase sticking to it. These extracted particles may then be examined directly in the electron microscope and their crystal structure determined by electron diffraction. Direct carbon extraction replicas are being used for examining the structures of the complex alloy steels required in the construction of jet engines. These steels must be able to withstand high stresses at temperatures of 600°C without much permanent deformation. Such properties are achieved by adding alloying elements which combine with the carbon in the steel to form alloy carbides within the grains of iron. An example of the microstructure of one of these materials, a steel containing chromium, molybdenum, and vanadium, is shown in Fig. 10. The electron micrograph is from a direct carbon extraction replica and the particles within the grains are of vanadium carbide.

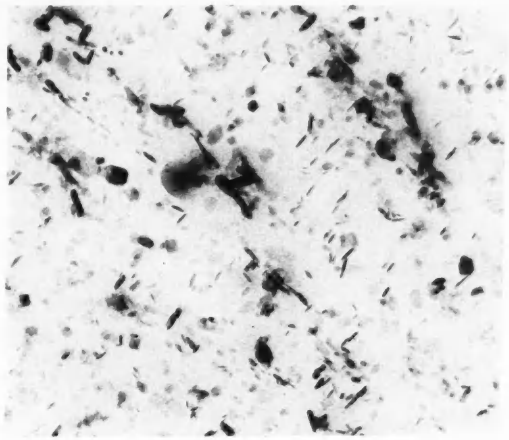
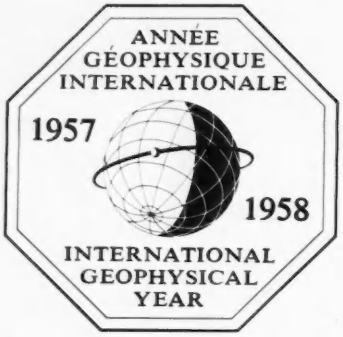


FIG. 10. Carbon replica from a tempered chromium-molybdenum-vanadium alloy steel. The structure shows tiny carbide particles within the ferrite grains and at the ferrite grain boundaries. Magnification, ×30,000.

CONCLUSIONS

The microstructures of metals and alloys result from the way in which the different atoms present aggregate, and how these various aggregates are distributed relative to each other. With certain new techniques for the microscopic examination of metals it is believed that the smallest size of aggregate which is thought to exist can be seen. The only structural possibilities remaining are to see directly how the atoms are distributed in a pure metal, a solid solution, or a compound, and to see the disturbances caused by the presence of a dislocation in a regular crystalline array. Some progress has been made towards these objectives. Dislocations have already been found in the molecular arrangement of thin crystals of organic compounds, whilst the strain fields around dislocations in thin metal foils of aluminium and stainless steel have recently been observed with the aid of the electron microscope.

In the fifteen years which the electron microscope has been used for examining metals a one hundredfold improvement in resolving power over the light microscope has been achieved. With a further tenfold improvement all the structures thought to exist in a metal should become visible.



THE INTERNATIONAL GEOPHYSICAL YEAR

MONTH BY MONTH

Compiled by Angela Croome

Fifty-five Countries Now

Since the CSAGI conference at Barcelona four more countries have announced their intention of joining the IGY. Rhodesia and Nyasaland, Ceylon and Ecuador communicated their decision in the autumn. Guatemala notified the Secretary-General on November 13 that a national committee had been formed.

This brings the total of countries participating up to fifty-five, and more may still come in.

Scientific Uses of Earth Satellites

About a year ago the American Upper Atmosphere Rocket Research Panel devoted its entire tenth anniversary session to specific and detailed proposals for research from small artificial earth satellites. The IGY satellite vehicle was very much in mind throughout the proceedings. The University of Michigan Press recently published the papers given at this meeting as a book, "The Scientific Uses of Earth Satellites". This month it will appear under the imprint of Chapman and Hall, price 3 gns.

The book provides the most detailed account so far available of the satellite's internal instrumentation. Besides this, it gives precisely and in detail twenty-four proposed experiments that might be conducted from a small satellite. (Thirty-one competent suggestions had been placed before the IGY satellite Technical Panel by autumn last year.) The name of the Editor, James A. Van Allen (chairman of the American IGY working group on the satellite's internal instrumentation), and those of a number of the other contributors, testify to the authority of these papers.

The following is a slightly condensed summary of the list of proposals put forward in the book. A star * denotes that high priority was given to the particular experiment in the preliminary statement by Dr Van Allen last September. A † indicates that the experiment was included in the list of eight that have been adopted for the first satellite to be launched (see DISCOVERY, May 1956, pp. 206–7):

The measurement of temperature*†, meteor penetration and surface erosion*†.

Insolation of the upper atmosphere.

Air density measured by calculating satellite "drag"† and other means.

Meteorological measurements (including cloud cover).

Measuring atmospheric temperature by spectroscopic means.

Visibility from a satellite.

Lyman-Alpha experiment for monitoring the intensity of ultra-violet and x-rays*†.

An experiment for determining the distribution of hydrogen in the upper atmosphere.

Study of ultra-violet stellar magnitudes.

Quantitive intensity measurements in the extreme ultra-violet.

TABLE I.

The development position of the minimum components necessary for effective satellite instrumentation, May 1956

	Production Quantities available	*Laboratory Quantities available*	*Development required*	*Basic Research and Development required*
POWER SOURCES				
Primary Batteries	x			
Storage Batteries	x			
Solar Devices		x	x	x
Nuclear Devices			x	x
ELECTRONIC PARTS				
Capacitive Elements	x			
Inductive Elements (Coils, Transformers, Anodes)	x			
Resistance Elements	x			
Frequency Control elements up to 125 mc/s.	x			
elements up to 200 mc/s.		x	x	
Electromechanical Elements	x			
ELECTRON DEVICES				
Subminiature Tubes up to 150 mc/s.		x	x	
Germanium Transistors up to 150 mc/s.		x	x	
Subminiature Tubes up to 300 mc/s.			x	
Germanium and Silicon Transitors up to 300 mc/s.			x	x
SHIELDING MATERIAL	x			
THERMAL ENGINEERING Material	x		x	x

(By courtesy of Dr. Hans K. Ziegler, Messrs. Chapman and Hall, and University of Michigan Press.)

FIGS. 1 and 2. Personnel of the U.S. Navy "Operation Deep-freeze" continue to test equipment and operational techniques against the rigours of the Antarctic. *Above*, an aerial view of Williams Air Operating Facility at McMurdo Sound in Antarctica. *Below*, the U.S. Navy's Task Force continues "Operation Deep-freeze".

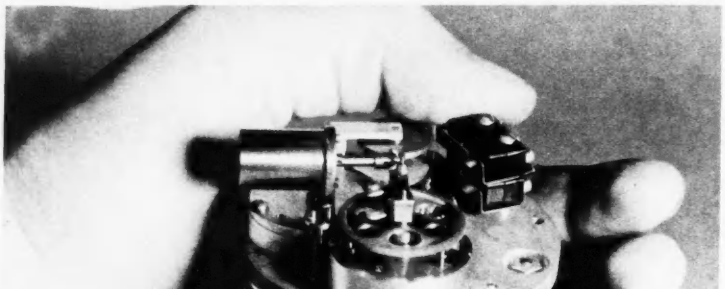


FIG. 3. A miniature tape-recorder developed by the State University of Iowa for storing readings within U.S. earth satellites and playing back to ground stations at 100-minute intervals.

Cosmic-ray observations*†.
Study of the arrival of auroral radiations.
Measurement of solar stream protons.
Geomagnetic measurements.
Determination of ionospheric structure.
Determining ionospheric temperature and electron density by means of a Langmuir probe.
Studies of propagation in the ionosphere from a satellite (two methods).
The study of the fine structure and irregularities of the ionosphere.
Meteoric bombardment†.
Measurement of interplanetary dust.

Another interesting group of papers deal with the minimum instrumentation considered necessary to make the satellite venture worthwhile, and the development position of the various components at the time of writing. The accompanying Table I. sets out this information.

The writer on instrument-systems-design emphasises a point that may be easily overlooked. It is that although much of the necessary equipment for the satellite has been developed and proved in ten years of American rocket research, the satellite's instrumentation must be two orders of magnitude lighter than for rockets and last up to five orders of magnitude longer. This means "miniaturisation" to the limit (see Fig. 3).

Australia Joins the Rocketeers

It has now been announced that Australia, besides providing facilities at Woomera for firing the British research rocket Skylark, will operate a rocket of her own. It will be of the "rockoon" type with a ceiling of at least 100 miles. The launching will be a joint enterprise with the United Kingdom.

No details are yet available of the Australian research programme about the rocket, nor of the type of propulsion system used, nor where the rocket is being designed and made.

Bristol Aircraft Ltd. revealed recently that a second launcher for the Skylark is being constructed at the Aberporth guided weapons range in South Wales. This shows some confidence that Skylark's flights will prove reasonably predictable during the Woomera tests. A launching tower is 80 feet long and weighs 30 tons. Skylark made its first flight at Woomera on February 14. It rose 10 miles.

The Bristol company is building the Skylark's rocket motor, called the Raven, in collaboration with the Royal Aircraft Establishment.

Antarctic at Bay

Conditions in the Antarctic appear to have been at their most unpredictable during the few weeks at the end of December and the beginning of January, when the expedition ships were closing in on the continental perimeter. All parties made safe arrivals, but the journeys were not without incident.

For the second year running the Trans-Antarctic party was nearly trapped in the Weddell Sea ice. With the aid of reconnaissance from the expedition aircraft, *Magga Dan* got clear in a few days. The delay, however, enabled *Tottan*, carrying the Royal Society expedition's additional

FIG. 4. Dr G. Hass, at the U.S. Army Corps of Engineers Research and Development Laboratories, Fort Belvoir, Virginia, makes final inspection of vacuum tank in which the first Earth Satellite will receive a special test coating to protect its delicate instruments from extreme temperatures and to provide a reflective surface which will enable the satellite to be more clearly seen.

stores, to overhaul her larger rival and reach Halley Bay first by four hours, although she had left England a week later. Royal Society Base at Halley Bay was relieved on January 4; Shackleton, the Trans-Antarctic depot in Vahsel Bay at the head of the Weddel Sea, on January 13.

During Dr Fuchs' stay at Halley Bay a flight was made in his expedition's aircraft in a north-easterly direction, to the Caird Coast area, to investigate a range of mountains that Lt-Cdr Dalgliesh had seen from Royal Society Base in October. This must have been by a freak effect of refraction, for though the mountains proved to exist, they lay 230 miles away. Thus Lt-Cdr Dalgliesh has disclosed an entirely new topographical feature of the area. The summit of the range is about 9000 feet high, and it extends 50 miles. Lt-Cdr Dalgliesh has named his discovery the Tottan Mountains after the Royal Society's ship.

Some days before the British ships arrived the U.S.S. *Staten Island* passed down the coast, headed for the western end of the Filchner Ice-shelf where the Weddell station is to be established. Before she reached her destination, however, she lost a propeller blade to the rapacious Weddell Sea ice.

Early in the New Year, on the other side of the continent, in the Ross Sea area, the section of the American task force detailed to set up the Vincennes Bay base on the Knox Coast was thrown into difficulties by a furious gale. Icefloes a hundred square miles in extent, driven before the wind, trapped the U.S. transport *Arneb*, pinning her against the coast, off Cape Hallett. While helpless in this position a second floe crashed into her, tearing a five-foot hole in her hull, luckily above the water-line, but also buckling her seams and damaging her propeller. Her escorting ship, the icebreaker *Northwind*, managed to get alongside before the pack closed in.

The same gale that caught the American ships off Cape Hallett swept over the little *Endeavour*, which was carrying the New Zealand scientists and explorers. The crate containing the Beaver aircraft which was stowed on deck was damaged and the dogs' cages smashed; several huskies narrowly escaped being washed overboard. A roll of 47° was recorded!

On arrival at McMurdo Sound the New Zealanders were further hampered—by the heat. The intention had been to ferry stores by Weasel and dog-sledge from *Endeavour*'s mooring, across sea ice to Butter Point on the mainland. This proved impossible because of the slushy surface due to an unusually warm spell. After several abortive attempts to reach Butter Point, the plan was abandoned, and Pram Point, which Scott used in 1911, was chosen as the site for the base. A few days later a party pioneering the route on to the Polar Plateau up the Ferrar Glacier had to turn back, also because of the melting ice surface. Another route has had to be found.

The same warm conditions and the resulting partial thaw of bay ice brought tragedy to the Americans at Williams air base, McMurdo Sound, in January. A snow tractor engaged on moving heavy equipment broke through the ice and a man was drowned; five others escaped. (Both the Americans and the Russians lost a man and a vehicle each in similar accidents last season—in fact Williams base is named after the American.)

While the expeditions in the Ross Sea area were experiencing these vicissitudes of Antarctic weather, the Australian relief party approaching Mawson in *Kista Dan* ran into unusually heavy pack ice; 40 miles of impenetrable pack screened the base from the sea. The expedition leader aboard ship therefore reversed the schedule and set a course down the coast for the Vestfold Hills, 360 miles from Mawson, where the second Australian base was due to be established this season. At first it seemed that the ship would not be able to get through to this point either, and plans were laid for setting up the second base at Prydz Bay instead. Reconnaissance by the expedition's new Beaver aircraft, however, disclosed a passage through to the Vestfold Hills. The new base was established on January 14 and named Davis Base after Capt. J. K. Davis, an Australian Antarctic expert and former Commonwealth Director of Navigation.

The Russians seem to have been more fortunate than the Anglo-Saxons. The *Ob* reached Mirny on Christmas Eve after "an unexpectedly easy passage through the ice". The *Kooperatsiya* put into Cape Town to take on board the American meteorologist who is to spend a year working with the Russians, and arrived at Mirny on January 10.

Antarctic Supplies Direct from Russia?

At one time the Russians intended to fly in supplies to the Antarctic direct from Russia—Siberia is a matter of a round 12,000 miles from Mirny—and they may still do so. It could be done in three hops of about 4000 miles each, with staging points in China and Australia. All the preliminary clearances were completed with the Australian Government for the use of the aerodrome near Fremantle in Western Australia as a staging point. The Russians made exhaustive inquiries about facilities there, and were satisfied that runways, refuelling arrangements, and other matters were suitable. But so far they have not come.

Second Geophysical Year for Antarctic?

The Americans have recently suggested that the geophysical work in the Antarctic should be extended for another year after the IGY proper is over. The idea is that, with little additional effort, double the amount of information could be gained and the scientific benefit would then more nearly balance the financial and other expenditure.

This proposal, unexceptionable as it seems at first glance, has met with little response. None of the European governments affected are likely to be prepared to raise the extra money, comparatively small though it may be; and scientists have some objections to the scheme. For instance, there is no suggestion that the IGY as a whole should be extended for a year, and it is argued that if the Antarctic work as planned was continued in isolation it would lose most of its point.

Another consideration is that several countries already have continuing Antarctic research programmes—and stations. Britain has a long-term programme for the ten FIDS bases, and the Australians likewise, at their continental base of Mawson (which is permanent) as well as at Macquarie Island. It is not unlikely that, without further prompting, the New Zealanders may take more interest than previously in the Ross Dependency after their present investigations.

In fact there is more than a chance that if the point is pressed it may open up the vexed political question of Antarctic territorial claims, a question that with some success has been kept in abeyance during the IGY deliberations so far.

Balloons and Primary Particles

The physics staff at Bristol University under Prof. C. F. Powell, F.R.S., has been active for some years in cosmic radiation studies. The technique they have perfected is that of exposing 9-inch stacks of emulsion plates at altitudes of 100,000 feet or so, suspended from large polythene balloons made in their own workshops. The total year's output of balloons is expended at one grand launching that usually takes place in summer, sometimes in this country and sometimes abroad. Elements as heavy as iron have been detected; the even heavier elements are increasingly rare.

This programme will continue during the IGY and make its contribution to the total world-wide cosmic-ray effort. This year's launching is expected to take place in April in the Po valley, Northern Italy, where good results have been obtained before. The average recovery rate in recent years for successful flights is 60%. Equipment from unsuccessful flights can almost always be used again.

During the IGY, in addition to the continuing balloon programme and the reduction of these results, a regular 24-hour patrol for solar-flares is planned. As soon as there is a warning that a flare has started or is imminent, balloons will be launched carrying plates for exposure at height. Standard large met balloons of rubber

will be used and the launching can be done from the laboratory roof.

Some difficulties are envisaged, however. It will throw a considerable strain on a small staff to keep up a rota of lookouts day and night for eighteen months. And will the warning be sufficient? Ten minutes is said to be the most that can be expected.

Cambridge Plans for the 1958 Eclipse

On October 12, 1958, there will be a total eclipse visible in the Pacific, the only one during the IGY.

Considering that the path to be swept by totality is more than 9000 miles long, it is curious how it manages to avoid the islands that pepper the South Pacific. The eclipse begins at sunrise several hundred miles North-west of New Guinea, and ends at sunset just short of Valparaiso in Chile. The path of totality (which at its broadest is not 150 miles across) narrowly misses Samoa to the South and Tahiti to the North. Most of the observations require extremely rigid mountings for the instruments and a certainty as to position of the greatest exactitude, so ships are unsuitable.

The possible sites are a handful of tiny coral atolls rising just a few feet above the surrounding ocean, approachable only by canoe through the gaps in the heavy surf.

The Eclipse Commission of the International Astronomical Union, under the chairmanship of Prof. R. O. Redman, F.R.S., of Cambridge, has collected what preliminary data is available about these islets.

An expedition is planned by the Cambridge Observatories, and, on a basis of the existing information, preference lies at present with the Danger Islands (10°55′ S, 165°50′ W), a group of three islets none of which is larger than one mile in any direction, encircling a lagoon. They are expected to have the longest duration of totality of any of the possible sites, about 4 minutes. The islands, which are inhabited, are under New Zealand administration. At the recommendation of their national IGY committee, the New Zealand Navy has offered logistic support for a British expedition. Another possibility is that the several national expeditions that are expected to be taking part should share a ship, perhaps from the U.S. as the Americans are likely to mount a party. Dutch, German, French, and Italian teams may also be expected.

One of the experiments to be undertaken by the Cambridge astronomers is already at an advanced stage of planning.

Dr H. von Klüber is concerned with measurements of temperature in the middle and outer reaches of the solar corona. He has been perfecting an experiment to this end during the past few eclipses.

Observations of the green emission line in the solar corona are made using a Fabry-Perot interferometer. The apparatus is extremely sensitive both to temperature and motion, and Dr Klüber therefore faces a ticklish problem in staging his experiment on a remote tropical island where even the vibration from nearby breakers is a factor to be taken into account. On the other hand the green emission line in the corona near sunspot maximum may be as much as ten times brighter than on the last occasion, in 1954, when he attempted the experiment and with relative success.

NEW SCIENTIFIC INSTRUMENTS

Two New Camera Microscopes

A Report by Kenneth G. Moreman, A.I.B.P., A.R.P.S.

Dr Kurt Michel, well known for his design work with Zeiss Winkel at Göttingen, has now been transferred to Carl Zeiss at Oberkochen/Württemberg, and from that remarkable post-war factory information has been obtained about two new microscopes. In them the photographic apparatus has been made an integral part of the design, and not just as accessories to be fixed to the microscope when photographs are required.

The larger and more complex instrument is the Ultraphot II, designed primarily for 9 by 12 cm. plates, but by the use of adapters material as big as 13 by 18 cm. (without automatic exposure mechanism) and as small as 35 mm. film can be accommodated. A general view of the instrument can be obtained from Fig. 1. Lighting is by a 12-volt 100-watt bulb which may be used either for transmitted or incident illumination; when two lamps are available both types of lighting can be employed simultaneously. Besides the tungsten lamp, a high-pressure mercury vapour or xenon lamp can be used, or

FIGURE 1

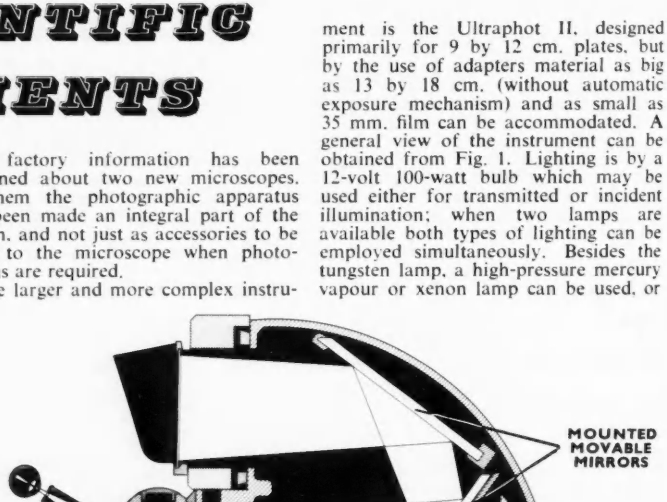


FIGURE 2

a fully automatic carbon arc. As can be seen from the illustration, the lamp housing is on the outside of the microscope thus ensuring adequate cooling and little or no heat transmission to the body of the instrument. The range of magnification normally obtainable with this instrument is from 2:1 to 1700:1. The lower range, i.e. from 2:1 up to 70:1, should really be obtained by using photomicrographic objectives, the "Luminars"[1], although down to 20:1, magnification can be obtained in the normal way. Using the "Luminars" comprehensive survey photographs can be produced with specimens up to 60 mm. in diameter.

The Ultraphot II incorporates a photomicrographic camera fitted with fully automatic exposure mechanism. When the specimen is in focus and the sensitive material inserted (this operation sets the shutter whether it is open or closed) it is only necessary to press a button to open the camera shutter. The exposure time is then automatically adjusted to the correct value, depending on the intensity of illumination. Before using the exposure regulating device, however, it must be calibrated for the type of plate in use, and the selected method of development. A sensitivity selector is incorporated for this purpose which can be adjusted by steps of 2/10° DIN.

The automatic exposure mechanism, presumably based on a feed-back circuit, can only be used for bright field images. Under other lighting conditions exposure is entirely under the control of the operator and is operated by an electro-magnetic release.

Other refinements on this instrument include the "optovar system", whereby the ocular magnification can be changed by the factors 1·25, 1·6, and 2, and an auxiliary microscope for observing the objective aperture, as is done when centring phase-contrast objectives. Fig. 2 shows a semi-diagrammatic section through the Ultraphot II arranged for transmitted bright-field illumination. The projection distance can be varied up to a maximum of 30 cm. by the horizontal displacement of two directly connected mirrors mounted on a mirror carriage, whilst the scale of the focused image may be found by reference to a calibrated drum. All the known methods of dark-field, bright-field, phase-contrast, and oblique-light observation in transmitted as well as in incident light are possible, and in every case the optical path of the light is in accordance with Köhler's principle of illumination.

The Standard Mikromat uses miniature film only, and its general appearance can be gained from Fig. 3. When the button on the base of the instrument is depressed the following sequence of operations takes place. The shutter is opened and the exposure is

[1] "Close-up magnification with the Contax and Luminars." Dipl. Opt. Rudi Kaiser. *Photogr. u. Forsch.*, December 1955, vol. 6, No. 8, pp. 238–50.

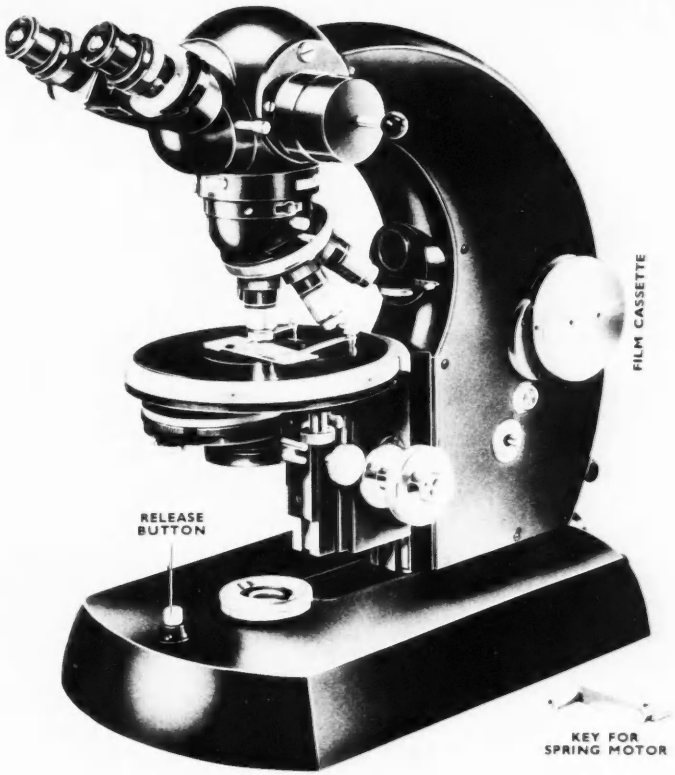


FIGURE 3

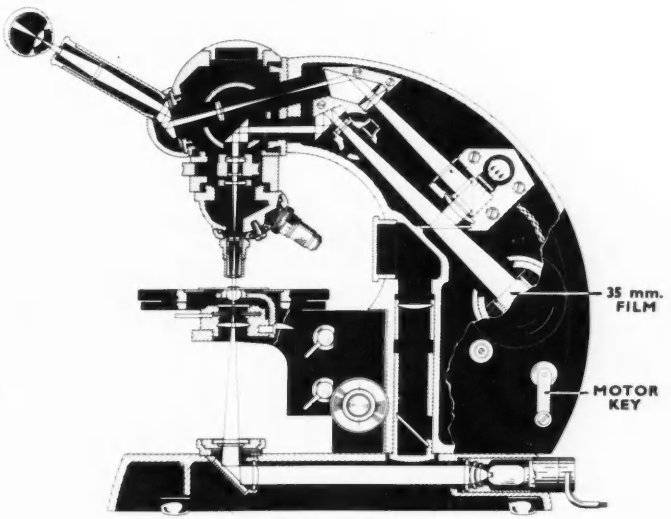
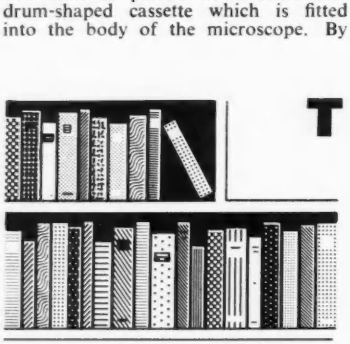


FIGURE 4

automatically regulated. The shutter then closes. The film is wound on one frame which is recorded on a film counter. Finally the shutter is reset. These movements are actuated by a spring-driven motor which is wound up once only, when the film is inserted. The film is placed in a removable drum-shaped cassette which is fitted into the body of the microscope. By rotating it slightly it is securely fixed, coupled to the drive, and opened. When completely exposed the transit mechanism is stopped, whereupon the film may be rewound and removed. The illumination comes from a 6-volt, 15-watt, high-intensity lamp which is built into the base of the instrument. The path of the light from lamp to film can be seen in semi-diagrammatic form in Fig. 4.

The United Kingdom agents are Degenhardt and Co. Ltd., 32 Maddox Street, London, W.1, who say that the Ultraphot II should be available in this country in July or August this year and is expected to cost £900 to £1000. The Mikromat should arrive by the end of the year and should retail for about £600 to £700.



THE BOOKSHELF

The Secret War: 1939–1945

By Gerald Pawle, with a Foreword by Nevil Shute (*London, George Harrap, 1956, 292 pp., 23 plates, 18s. net*)

In the summer of 1940 a new form of protective armour, made of bituminous cement with a stone filling, was devised for the Merchant Navy. This Plastic Armour, as it was called, was tested at the Naval Gunnery School at Whale Island, and the report read: "There is no doubt that Plastic Armour is very greatly superior to any other non-magnetic material so far tried.... It is most strongly recommended that the fitting of concrete protection should be discontinued and Plastic Armour fitted in its place."

The Department of Naval Construction was the Admiralty organisation officially responsible for all matters connected with armour. What was their reaction to this revolutionary new material which might be the saving of thousands of lives in the Merchant Navy?

One official said, "It is not necessary to try this so-called armour—there's nothing new in it. . . ." A docket asking for approval to fit the armour was returned with the comment that it was waste of time. H.M.S. *Excellent* was reproved for carrying out trials which had not been originated in the Department. But finally, after the First Sea Lord and other high Admiralty officers had given their approval to the new protection, the DNC withdrew their opposition on the condition that the word "armour" was dropped!

This fantastic story is only one of many instances of official opposition and inertia that Mr Pawle cites in his book. The word "fantastic" does not imply that the stories are not well authenticated—there are too many persons concerned and mentioned by name for the accounts to be exaggerated or invented. But it is almost unbelievable that at a critical time in the war there should exist such a mentality in a Service that the nation was relying on for its existence.

Then there is the story of the Oerlikon gun: ". . . no factory because there were no machine-tools, and yet the Admiralty were not entitled to any machine-tools unless they had a factory to put them in".

This book is not mainly a record of frustration—on the contrary, it is an account of the triumphs of a department in the Admiralty "which had no exact counterpart in the whole complex Allied machine which waged the Second World War against Germany and her confederates". The Directorate of Miscellaneous Weapon Development was formed during the fall of France; and under the direction of Charles Goodeve (now Sir Charles Goodeve, K.B.E., F.R.S.) it originated some of the most ingenious and effective war weapons that have ever been put to use against an enemy who, while being both ingenious and daring, failed to show that spark of originality and disregard for official routine which animated Goodeve's team.

The author describes the conception and working-out of those inventions of which the man-in-the-street heard only the final reports—the rocket guns, the Hedgehog anti-submarine charges, sky cables, floating runways and landing-platforms, and Mulberry harbour. In the main the book is a tribute to Goodeve, the driving force behind the team, but there are many other names that have gone almost unnoted in the acknowledgments paid after the war to inventors. There was R. M. Hamilton, who inhabited a derelict wing in the Grosvenor Hotel to experiment on floating runways; Alec Menhinick, who was twice shipwrecked while testing rockets; L. H. Lane, originally an expert in tree culture, who became a founder-member of the department and an expert on explosives. Incidentally, it was this Lane who was instrumental in having Barnes Wallis's block busting bomb adopted in the face of official discouragement.

Nevertheless, in his Foreword to the book, Nevil Shute (himself a brilliant worker in the team) says: "Without Goodeve the department could never have come into being." On reading through the absorbing account of the successes and failures of the leader and his colleagues, one is slightly envious of this small body of men who throughout the war were doing something vital, something exciting, and enjoyed doing it.

"The Secret War" is not just another war book. It is an inspiration and a lesson. The inspiration is obvious: the lesson is perhaps not so obvious, and will probably be wasted on permanent officials who are so deeply in the groove that they cannot realise that red tape is only made to tie securely in peacetime. Anyone who had anything to do with war weapons or has now to do with war weapons should buy this book and keep it to read again and again.

G. PARR

Atomic Weapons and East-West Relations

By P. M. S. Blackett, F.R.S. (*Cambridge University Press, 1956, 107 pp., 8s. 6d. net*)

Here is a thought-stimulating little book which should be widely read. It is based on the Lees Knowles lectures in Military Science given in 1956 by Prof. Blackett at the invitation of the Master and Fellows of Trinity College, Cambridge. Students of international affairs, military science, and indeed all intelligent persons interested in current affairs, will find the book interesting reading.

The first section outlines Western military and political thinking on the role of atomic and hydrogen weapons in military planning, especially under conditions where it is anticipated that both East and West possess saturation stockpiles of nuclear weapons. In the second section the important facts relating to the new weapons, their carriers and possible defences against them are discussed and provide the background for consideration of present controversies. In the final section Prof. Blackett gives his assessment of the most important factors, political and personal, drawn from the multitudinous events of the past decade which have lead to the present climate of opinion. The author concludes with

available shortly from your bookseller

INDUSTRIAL DEAFNESS

Joseph Sataloff MD

This is the first book specially written as a guide for industries interested in solving problems of deafness and noise. It will be useful not only to otologists and specialists in industrial medicine but to all factory inspectors, safety engineers, public health officers and executives in industries where noise is difficult to reduce.

Blakiston Division **60s**

STERILIZATION IN FOOD TECHNOLOGY **theory, practice and calculations**

C. O. Ball and F. C. W. Olson

Those concerned with the production of food or drugs, quality control or food research will be interested in this new book. It deals with the sterilization of food by lethal energy, especially in the canning processes. The effects of the sterilization may now be predicted by mathematical methods.

McGraw-Hill Series in Food Technology **120s**

McGraw-Hill Publishing Company Limited

Important Books

Statistical Methods and Scientific Inference

By Sir Ronald A. Fisher, Sc.D., F.R.S.

An examination of the logical nature of uncertain inference, including the concept of Mathematical Probability, which will be of the greatest interest and value to all concerned with statistics. **16s.**

Jurassic Geology of the World

By W. J. Arkell, D.Sc., F.R.S.

This book presents, for the first time, a synthesis of a geological system all over the world, based upon correlation of marine faunas: it is arranged geographically as a reference work and has an additional section dealing with general problems such as continental drift, etc. **£5 5s.**

Principles and Applications of Physics

By Otto Blüh, D.Sc., and Joseph D. Elder, A.B., A.M.

Original in its approach, this thought-provoking text is distinguished by its advanced method of presentation and its emphasis on the border-fields of physics and the inter-relations of physics with the humanities. **45s.**

Oliver & Boyd

Galactic Nebulae and Interstellar Matter [63*s.*]

JEAN DUFAY

Translated by A. J. POMERANS

"Provides the most complete account available of the many diverse phenomena, observational and theoretical, involved in the study of interstellar matter."—Sir H. Spencer Jones, *Endeavour*.

Fully illustrated.

Contemporary Physics [18*s.*]

C. v. WEIZSÄCKER and J. JUILFS

Translated by A. J. POMERANS

A survey of the entire field of physics, both classical and contemporary. It gives a sound conception of what physics has achieved and what it is up to.

Illustrated.

Light, Vegetation and Chlorophyll [15*s.*]

J. TERRIEN, G. TRUFFAUT and J. CARLES

Translated by MADGE THOMPSON

This useful exposition consists of the two works, *Lumière et végétation*, by Jean Terrien and Georges Truffaut, and *L'Energie chlorophyllienne*, by Jules Carles. The first work deals chiefly with the requirements and utilisation of light by plants, and the second with the chemistry of chlorophyl and photosynthesis.

Illustrated.

High Speed Flight [30*s.*]

E. OWER, B.Sc., and J. L. NAYLER, M.A.

This book explains with a minimum of technicality the human and mechanical problems of very high speed and supersonic flight.

Fully illustrated in line and half-tone.

Hutchinson

Scientific and Technical Publications

a brief outline of his views on the guiding lines of future military policy.

The book contains much which is highly controversial. Thus, to this reviewer, the statement that the last war was won by the Allies primarily by their superiority in numbers over Germany, and not by any overall technological superiority, is misleading. It grossly underestimates the technical superiority of British aircraft; after all the Hurricanes and Spitfires, though too few, did prevent our losing the war. And again the part played by radar in winning the Battle of the Atlantic, and later, in carrying the air attack to Germany, was vital and stemmed from British technical superiority.

Prof. Blackett believes that the new weapons are so devastating that all-out war is now highly unlikely. I hope he is right; if we have to deal only with rational and logical opponents there is much to be said for this view. But the seekers after great power are not noted for rationality; one only has to remember Hitler. Outbreak of war, even "limited" war, will always bring with it the danger that, as a last throw, a Hitler of the future would plunge civilisation into ruins.

E. W. TITTERTON

A Guide to Qualitative Organic Chemical Analysis

By R. P. Linstead and B. C. L. Weedon (*Butterworth's Scientific Publications, London, 1956, Academic Press Inc., New York, 169 pp., 21s.*)

Most students of practical organic chemistry find the period devoted to identification of organic chemical compounds, aptly called "spots", completely fascinating. Each exercise is a research in miniature and many qualities, such as those of keen observation, retentive memory, and logical deduction, contribute to a successful outcome. The whole detective process is stimulating, and to run the quarry to earth is a triumph.

Nevertheless, some guidance is desirable in order to avoid floundering in a morass of unfamiliar reactions. The present work is the best attempt yet made to accept the challenge of a rather intractable problem. It succeeds admirably, and reaches its avowed educational objective; but, perhaps fortunately, it does not do away with the necessity for individual enterprise. The student who follows its general precepts and special advice will certainly be helped to avoid waste of time, but there is no fool-proof system in this domain of analysis.

The book is based on many years of teaching experience in the chemical laboratories of the Imperial College of Science and Technology, South Kensington, and its scope has been influenced by the research interests of the school. Within its self-imposed limits it is quite excellent and is a sound investment of a guinea. It is well printed, free from typographical error, and will doubtless come to be regarded as the standard work in the field. Criticism on technical grounds is possible, but the details are hardly of sufficient interest to the general reader to mention in this place. They do not affect the value of this most original contribution to organic chemistry texts in a hitherto almost stagnant region.

ROBERT ROBINSON

The World We Live In

Edited by the Editorial Staff of *Life* and Lincoln Barnett (*London, Messrs. Collins, 1956, 304 pp., 340 full-colour pictures, £4 4s.*)

This is an inspiring book. It is impossible to see it without opening it, and, having opened it, to resist turning over its pages. It tells the story of the evolution of the earth and of life upon it with a vividness which could not have been achieved without illustrations of the excellence, number, and size which it contains. Photographs of natural phenomena of the present day take their place beside reconstructions of events in the remote past, thereby illustrating the importance of the great principle of uniformity. There are, no doubt, in this synthesis propositions from which some specialists will be found to dissent; but this cannot in any way impair the welcome which it deserves. Readers of *Life* will remember having seen it in instalments a few years ago. They, as well as those who have not, will be glad to have these articles collected together into so fine a volume.

GAVIN DE BEER

Thinking by Machine

By Pierre de Latil, translated from the French by Y. M. Golla, with an introduction by Sir Walter Puckey (*London, Sidgwick and Jackson, 1956, 353 pp., 8 illustrations, 45s.*)

Pierre de Latil's book was published three years ago in France, and has now been translated into English. Much of what the book describes is now well documented and well known in scientific, certainly cybernetic, circles. This does not detract from the interest of the book or the special emphasis that de Latil gives. His account has the advantage of making no demands on the mathematical or neurological knowledge of his readers; it is a work of high-class popularisation.

Emphasis is placed on practical aspects of cybernetics, which has been so much a European part of what is an international movement. The admirable work of the two British pioneers of cybernetics, Drs Grey Walter and Ross Ashby, comes in for fairly detailed analysis. Cora, the conditioned reflex analogue, and especially the tortoises, that have given such pleasure and aroused such interest to many people, are described in detail. So also is Ashby's homeostat.

A rather special philosophical view underlies the whole work. It is a view essentially in keeping with cybernetics, in that it relates machines to organisms, and indeed regards the theory of control and communication as applying to machines and organisms without distinction. A special chapter is devoted to what de Latil calls the *logic of effects*. This logic, of an empirical kind, is used to analyse the behaviour of machines. The view is that certain factors operate on a system and produce effects. Then it is said that an effector is a natural or artificial system which produces a certain effect. From this it follows that a machine is an artificial effector. Factors can be broken down into prefactors, and so on, and components of effectors and secondary effects occur at the output end.

In the same novel terminology, de Latil builds up an account of machine activity, talking in terms of constancy effectors (feedback control with constant output), tendency effectors (where the input is used to maximum effect on the output), regulation by interaction, retroaction, and so on. Retroaction, it is claimed, is equivalent to negative feedback and is central to automatic control. There is a curious ring about the terminology that takes all the ideas familiar to cyberneticists, communication engineers, and the like, and reformulates the whole outlook in very general terms. The terminology and viewpoint are amply illustrated by mechanisms from every sort of field.

The question arises whether such a new terminology is necessary. There is no harm in using such terms as de Latil's, but the familiar terminology of input-output, or stimulus-response, were adequate and have been widely developed.

More important than the new terminology is the taxonomy of machines. The lowest order in terms of determined effects is the simple tool, such as a hammer. We work up through the first-, second-, and third-degree determined effectors, which can be illustrated by a piano-key, calculating-machine, and automatic fire-alarm respectively. At this point cybernetics starts. Thus fourth-degree effectors include the automatic pilot, and then beyond classical machines, with Ashby's homeostat at the fifth degree, and so on, up to the eighth degree. These various stages are distinguished in terms of the aptitudes of the various systems, degree of coordination, determinism, stability, and so on. Their power supplies and their overall organisation are also taken into consideration. An extremely interesting attempt is thus made to give a systematic and well-organised account of cybernetics. Much is also said of related science and automation, and the problems of the automatic factory, the design of calculating-machines, and game-playing machines, which are old friends to people interested in this field of study.

The disadvantages of the book are that it dwells on too limited an aspect

of cybernetics. It would have gained in effectiveness had it given some account of finite automata and Turing machines, and made some mention of the work done in meta-mathematics. These omissions make de Latil's account seem slightly artificial, an effect somewhat increased by a rather unpalatable, racy sort of journalistic style, often almost coy.

This book should be read by all people interested in cybernetics; those not yet acquainted with this new and exciting field of endeavour will get a somewhat one-sided view of what has happened, and could safely include it in their reading only if they are prepared to read a great deal more besides.

F. H. GEORGE

The Brabazon Story

By Lord Brabazon of Tara (*London, William Heinemann Ltd., 1956, 220 pp., 25s.*)

Lord Brabazon is widely known in scientific circles as the President of the Royal Institution and for his pioneering work in the field of aeronautics before the First World War. It is therefore a great pleasure to read his own account and comments of those heroic days. "In fact, if you put half a gallon of petrol in and took your coat and boots off, you were liable to get a flight of about one hundred yards." It was a machine bought from the Voisin brothers in 1908 which put up this satisfactory performance. During the 1914–18 war Lord Brabazon pioneered the development of another branch of aeronautical science, aerial photography. In his charming and highly informal style, he describes how the Photo Section of the R.F.C. did some great work, for example the taking of stereo photographs of trenches from a height of 12,000 ft., and how he himself designed a vibrationless camera-mount which eliminated all angular movements of the camera. This invention brought him the honorary fellowship of the Royal Photographic Society.

Lord Brabazon was outstanding in many other fields of life. He was an ardent motor-racing driver, a balloonist, a superb golfer, a Member of Parliament and later a Minister of Transport, a frequent winner of the Cresta run in St Moritz, a yachtsman, a director of Kodak Ltd, and finally, to crown his varied career, a member of the House of Lords. He sums up his life in the words, "What a privilege from the Almighty to have enjoyed the adventure of life." Few men can have enjoyed a more varied adventure than Lord Brabazon.

A. R. MICHAELIS

The Open Sea

By Alister Hardy (*London, Collins, 1956, 335 pp., 30s.*)

The number and diversity of organisms living in the sea are such that it is difficult to convey a comprehensive picture to those who have not made a special study of the subject. Many popular books have been written about the sea, and since the war there have been an increasing number published. None has attempted to given an overall account of life in the open sea, and Prof. A. C. Hardy's book is unique in this respect. There has never been a book quite like it, and there never will be again, so many qualities being needed to produce so individualistic an outlook. That the author writes with enthusiasm and enjoyment is obvious, and this zest carries the reader through much descriptive matter which could make dull going were it not interspersed with biological asides and personal anecdote. In some respects the result is not coherent, but the subject is so vast that without much lengthier treatment it would be impossible to present the whole picture. As it was, the author found the original intention of writing one book on the open sea out of the question; and the present work, dealing only with the plankton, cephalopods, and oceanic fish, is the first of two volumes.

Man as an Animal

W. C. OSMAN HILL

Prosector to the Zoological Society of London

[10s. 6d.]

The theme is the animal nature of Man, with stress laid upon the relation of living beings to their environment.

HUTCHINSON UNIVERSITY LIBRARY

THE "SOLASCOPE"

GIANT ROTARY GUIDE TO THE SOLAR SYSTEM

Showing PLANETS and ORBITS to scale and revealing over 1000 facts and figures when rotated. Everything you want to know about the . . . SUN — MERCURY — VENUS — EARTH — MOON — MARS — JUPITER — SATURN — URANUS — NEPTUNE — PLUTO — Diameters, Distances, Velocities, Space Travel computations, etc. Approx. 12 in. square. Beautifully illustrated in full colour on stout fine-quality art and matt-surfaced printing boards. Double-side 3-piece construction showing all planets, 9*s.* 6*d.* post free; or single-side 2-piece showing Mercury to Mars, 5*s.* 6*d.*, or Jupiter to Pluto, 5*s.* 6*d.* Send P.O. to:

"SOLASCOPE" Dept. R., 44 London Road, Kingston, Surrey

Notes on Applied Science

Prepared by the National Physical Laboratory, this series is designed to provide industrialists and technicians with information on scientific and technical subjects not readily available from any other source.

Recent issues include:

No. 13 Standard Capacitors and their Accuracy in Practice **1s. 3d.** (*post 2d.*)

No. 14 Photometry of Binoculars and Telescopes **2s.** (*post 2d.*)

No. 15 Application of Spring Strips to Instrument Design **2s.** (*post 2d.*)

No. 17 High Voltage Impulse Testing **1s. 6d.** (*post 2d.*)

Others are in preparation

HMSO

from the Government Bookshops or through any bookseller

This volume is concerned not only with the description of typical forms of life, but also with a number of aspects of their biology and with the results of research and its bearings on the fisheries. The book is remarkable in that it is almost a biological textbook, describing in some detail the morphological characteristics and developmental stages of the different groups of life comprising the plankton, with the use of only a very limited number of technical terms. It is also remarkable because every page reveals the passionate interest of the author in his subject. We can picture Prof. Hardy, as he describes himself, sitting in a "bo'sun's chair below the jib-boom, on Capt. Scott's old ship *Discovery*, with his bare feet in the water and a dip net in his hand; or awaking at night in an inn to be alarmed by the luminescent flashing of ctenophores on his bedroom mantelpiece. So many also of the major problems of plankton life have been the subject of the author's own research that the book goes far beyond being a compilation of the results of the work of many scientists (which, of course, it is); it is an authoritative essay by one who is so close to the scene that he has himself almost become part of the story.

But not only has Prof. Hardy written this most fascinating book; he has also largely illustrated it himself with line sketches and with a number of attractively arranged plates of his own water-colour drawings. Most of these drawings were from life, and many have been painted while actually on board research ships at sea. Among the many illustrations the author has also been fortunate in having a fine series of electronic flash photomicrographs of living plankton animals from the hand of that leading photographer of marine life Dr D. P. Wilson.

The book can be commended unreservedly to all naturalists who wish to be introduced to a world of life not usually looked for but easily accessible if they follow Prof. Hardy's directions. It will undoubtedly prove invaluable to university students, making vivid and stimulating the picture that they only partially learn from textbooks and pickled specimens. It will also give pleasure to older biologists, like the reviewer, who, but for the limitations of space, could say much more to praise the account of larval stages and Walter Garstang's theories, and other interesting topics presented in "The World of Plankton".

The book is fully up to the standard of the best of the New Naturalist series, and we shall eagerly await the publication of Volume II on fish and fisheries.

F. S. RUSSELL

Rheology: Theory and Applications

Vol. I. Edited by F. R. Eirich (*New York, Academic Press Inc., 1956, xiv+761 pp., $20.00*)

This is a monumental work. The first volume (to be followed by two others) contains a short introduction by the editor and sixteen chapters by other well-known rheologists. Though most of the authors are American, Holland, Wales, Yugoslavia, and Israel are also represented.

It is impossible in a short review even to mention all these contributions; but the stress, in this first volume, is laid principally on General Theory (M. Reiner), Plasticity (W. Prager, D. C. Drucker), Crystal imperfections (J. G. Dienes, J. M. and W. G. Burgers), Metals (the late J. Fleeman and J. G. Dienes), Viscosity (A. Bondi), Large elastic strains (R. S. Rivlin), Macromolecular solutions (T. G. Fox *et al.*, J. Riseman and J. G. Kirkwood, H. L. Frisch and R. Simha), Stress- and flow-birefringence (A. Peterlin), Non-Newtonian flow (J. G. Oldroyd), and Acoustic phenomenon (R. B. Lindsay).

The standard is high, and the production excellent; though it is unfortunate that the name of such a well-known rheologist as Treloar is consistently misspelt throughout Chapter 15. Each chapter has its own table of symbols. Not only do the authors differ greatly, even in the case of such widely used terms as stress and strain, but in some chapters by no means all the symbols are listed. It is to be hoped that in the later volumes agreement may be possible, at least for all the commoner terms.

It is suggested on the jacket that the book "may well be the forerunner of a unified rheology". The chief task of rheologists is to study the relationships between forces, deformations, and flow of materials. Although, until recently at least, most industrial rheologists were concerned with "vector problems", it is clear that the use of the second-rank tensors of stress, strain, and flow-rate, and of fourth-rank products, affords a generalisation of individual "degenerate" cases, and in this sense tends to unify rheology; but it must be admitted that no other unifying influence is apparent in these very diverse essays.

It is intended that the book should be useful to scientific workers in research or production laboratories, but the reader is expected to be quite at home with tensor notation, Riemannian geometry, and various other mathematical techniques which are by no means always familiar to the industrial rheologist.

One wonders a little how much of this admirable book is really necessary! Most of the fundamental mathematical treatment is already available, often in textbooks and articles by the same authors as have written these essays. A limited amount of duplication of such material is useful and necessary in all branches of science; but one hopes that the sections on applied rheology, in later volumes, will follow a little less closely the treatments already given by the same authors in other textbooks.

G. W. SCOTT BLAIR

Grossbild Technik

Published quarterly. Obtainable from Rupert-Mayer-Strasse 45, Munich 25, West Germany. Annual subscription £1 3*s*.

This magnificent new publication brings to English readers a new standard in photographic magazines. The choice of illustration and quality of their presentation is outstanding.

The magazine has already been available to German readers for a year or two and appears to be produced by the makers of the German Linhof camera as a counterblast to the many excellent books and periodicals which have for so many years brought the advantages of the Leica 35 mm. camera before the public.

The magazine should appeal to all professional and amateur photographers, irrespective of the size of camera they use, and will be a real inspiration to them all. It is clear that the dramatic picture can be made by the large camera as well as by the miniature, although some of the pictures shown might be more easily obtained with a miniature. Wherever awkward perspectives with awkward verticals demand a camera with front movements, or the picture is large and yet full of fine detail, a camera such as the Linhof has obviously great advantages.

There are several articles in both the first and second issues which are of considerable interest, although it is the pictures which should cause every photographer to want to see this magazine.

H. JOHN JARROLD

Automatic Digital Computers

By M. V. Wilkes, F.R.S. (*London, Methuen & Co. Ltd., 1956, x+305 pp., 42s.*)

The experience gained in pulse techniques during the Second World War has made possible the development of computing machines which can carry out automatically, and at a very high speed, extended sequences of arithmetic operations. In the last few years the construction of these machines has passed from research to commercial production and the time is ripe for an authoritative account of the present state of the art. The author of this book has played an important part in the development stages both of the construction and the use of automatic computers and is well qualified to write such an account.

An outline is given of the history of automatic computers from the time of Charles Babbage up to 1945 when J. von Neumann described the fundamental features of the design of the new type of electronic computer, in which both the numbers and the instructions describing the arithmetic operations are held in the same store.

The logical design of an electronic computer and the preparation of programmes are then described. Both subjects are treated with special reference

to the computer, EDSAC, with which the author has been associated, but in each case there is a fairly complete account of the main differences between EDSAC and other electronic computers. The expositions are a model of lucidity and although the accounts are moderately detailed they could be read by a beginner without any previous knowledge of either subject.

The chapter on relay computers seems a little out of place, since this is a subject which is of less interest now than before the advent of electronic computers. It is followed by chapters in which are described the main forms of storage and the basic electronic circuits which have been used. The former chapter manages to compress a remarkable amount of information into a fairly short space without omitting any essential features. It includes a section on magnetic cores which are being used as the storage elements in the majority of the more advanced computers now under construction.

A final chapter discusses the factors to be considered when designing and maintaining a computer, and also the organisation of a group using a computer. All the main points are given careful consideration and my only criticism is that the author is a little too concerned to avoid appearing dogmatic.

This is an excellent book, and in spite of the fact that it deals with a rapidly developing subject it will be the standard work of reference for some time.

J. H. WILKINSON

Brief Notes

The second edition of "The Guinness Book of Records" has now been published by Guinness Superlatives Limited, Fleet Street, London, price 9*s*. 6*d*. It contains 264 pages of "potted" information on records of all types. In fact the book itself qualifies as a record of compression. The section on science contains a number of useful data not usually available in such a form. It gives in full, for example, the highest prime number yet discovered: 738 digits. The sections on the Natural World, the Animal Kingdom, and the Universe, are also of interest to the scientist who wants to know the extremes of great and small.

The Industrial Hygiene Foundation is an American Association for advancing industrial health and improving working conditions. The Mellon Institute, 4400 Fifth Avenue, Pittsburgh, Pa., U.S.A., has published a short historical booklet on the Foundation.

A booklet from the Federation of British Industries, 21 Tothill Street, S.W.1, entitled "Industry and the Technical Colleges", reviews problems of co-operation between industry and the colleges, recruitment from schools, supply of teachers, technological careers for women, and so on.

The October 1956 issue of the *Scientific Film Review*, published from 164 Shaftesbury Avenue, London, W.C.2, contains details of 145 films on atomic energy and related subjects. Copies cost 3*s*. 6*d*.

The Association of British Chemical Manufacturers, Cecil Chambers, 86 Strand, London, W.C.2, has published the proceedings of an "Instrumentation Appreciation Conference", with papers on such subjects as "Instrumentation as an Aid to Fuel Efficiency", "Economic Gains Resulting from Instrumentation", etc.

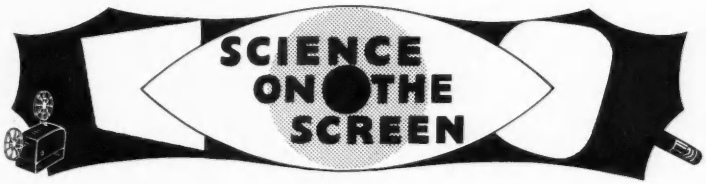
"Coal as a Raw Material" is the title of a monograph by W. Idris Jones published by the Royal Institute of Chemistry, 30 Russell Square, London, W.C.1.

Hopkin and Williams Ltd, Chadwell Heath, Essex, have published two monographs on organic reagents for metals, one on "Thorin", reagent for thorium, lithium, fluoride, and zirconium; and one on "Dithizone", reagent for lead.

"Aeronautical History in Pictures" is the title of a booklet published by the Science Museum, London, S.W.7, at 2*s*. It recalls and illustrates some historic events, machines and personalities in the development of flight, beginning with the Monrgolfier hot-air balloon which rose into the sky on November 21, 1783, and ending with supersonic fighters.

The British Council's Annual Report for 1955–6 is now available from 65 Davies Street, London, W.1. The report says that during the year high priority has been given to contacts between British and overseas scientific specialists.

A well-illustrated monograph on Crustacean Metamorphoses, by R. E. Snodgrass, has been published by the Smithsonian Institution, Washington.



The Ruthless One

A Shell Unit Film (35 and 16 mm.; sound; colour; 20 mins.)

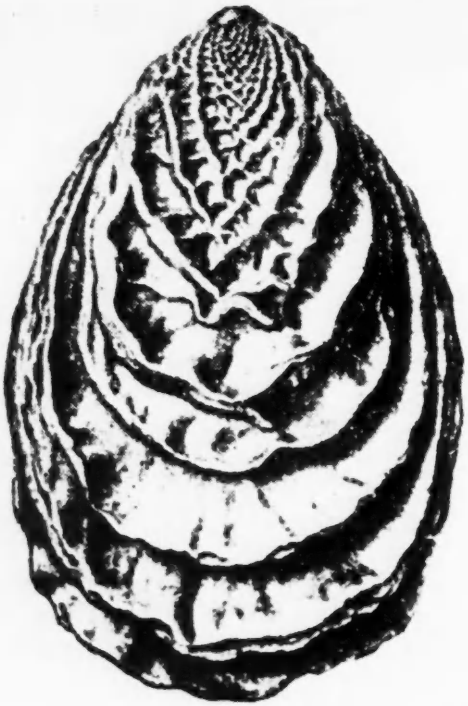
"Al Garad", the Ruthless One, is an Arabic name for the Desert Locust; a name entirely justified by the appalling severity of its depredations. The immense scale of the locust problem was very well presented in part of the film "The Rival World", made by the same unit; in particular, there were some memorable shots of locust swarms taken from aircraft.

This new film, "The Ruthless One", provides more detailed knowledge about the locust itself and gives a brief glimpse of the scientific studies responsible for advances in control measures. Some of the pictures were taken in East Africa including, no doubt, the dramatic opening pictures of a locust swarm from within. But these were merely to provide a background to the more important sequences, which were filmed in laboratories in England. The result is a very excellent study of the life cycle of the locust. The adults are seen mating; then the female lays her eggs, in a glass container allowing a clear view of the burrowing movements of her enormously extended abdomen. Even more impressive is the hatching of the young nymphs and their urgent struggles to reach the surface. Behaviour of the immature stages and the intervening moults complete the cycle which, while perfectly intelligible to a layman, would capture the attention of zoological students quite as effectively as painstaking demonstrations from actual locust colonies. In view of this it seems a pity that some details of the solitary and gregarious phases were not included. These two forms represent an important aspect of locust biology and the colour differences would have shown up well in the film.

The later part of the film illustrates some of the work of the Anti-Locust Research Centre in London. It attempts to describe the co-ordination of information on locust breeding and movements in different countries and also some of the research on control methods. Obviously it is difficult to cover these subjects adequately in the five or ten minutes available and one felt, just a trifle, disappointed. One would like, for example, to have seen more of the micro-drop shooting machine and the wind tunnel and to learn how they are used to solve problems of contaminating flying locusts with suitable poisons. However, the film is not designed primarily for scientists but for the intelligent layman; for example, in countries subject to locust devastation, it should be particularly interesting to authorities concerned technically, administratively, or educationally with the suppression of this pest.

Technically, the film was excellent. Some quite difficult photographic problems were successfully solved and the colour values appear to be just right. The commentary is interspersed with "background music" calculated to evoke eerie feelings of antagonistic subhuman forces.

J. R. BUSVINE



FAR AND NEAR

A Rare Shellfish

The photograph published at the top of this page shows a rare specimen of a shellfish which was believed to have been extinct for more than 350 million years. The discovery that it still exists was made by the *Galathea* Marine Research Expedition in May 1952 close to the Mexican coast. It has taken a long time to sift the amount of material gathered during the expedition, and the results have only just become known. The shellfish is 4 centimetres in length, and was discovered lying 11,000 feet below the sea level. Experts at Copenhagen's Zoological Museum have been examining the mollusc.

Science Broadcasts to Asia

A weekly half-hour programme broadcast to South and South-East Asia in the BBC's English programme will bring to the microphone the Heads of Departments, the medical men, and the scientists who are actually engaged in research in Great Britain. They will discuss their work-in-hand, its application to today, and its possibility for the future. Each programme deals with one subject only. Among those in the first series are: Blood Groups (Drs A. E. Mourant, H. Lehmann, and Fraser-Roberts, and Prof. Ian Aird); Movement of Cells (Dr M. Abercrombie); Radio Astronomy (Prof. A. C. B. Lovell); Pasteurisation or Sterilisation of Milk (Prof. H. D. Kay); Etiolation of Plants (Prof. W. T. Williams); Radioactive Isotopes in Medicine (Mr Raymond Greene and Dr A. Green); Man-Made Textiles (Prof. J. B. Speakman); Rheumatology (Prof. J. H. Kellgren); Skin Grafting (Prof. P. B. Medewar).

It is believed that "Searching Mind" is the first comprehensive programme of this type to be broadcast in the Overseas Service of the BBC, and the series will be rebroadcast to North America and other countries.

Science Masters Meet

The Science Masters' Association, which represents about 5000 masters in public schools and secondary schools, this year held its annual meeting in the University of Cambridge. About 750 masters and visitors attended. Mornings were devoted to lectures on various aspects of physics, chemistry, biology, human ecology, astronomy, and antarctic exploration, and afternoons to visits to University departments and local factories.

The meeting included exhibitions by publishers and by manufacturers of scientific apparatus. There was also the usual exhibition of apparatus devised or built by members themselves, and demonstrated in action; a portable radioactivity ratemeter, using transistors, was shown by Harrow School.

A special exhibition was arranged by the Aluminium Development Association, which showed a very complete display of products of the anodising process; another was by the National Coal Board, demonstrating methods of coal cleaning, etc. Other exhibits were contributed by the Gas Council, and by Pye Radio Ltd., which showed its latest underwater television camera.

Some schoolmasters who attend the meeting pay their own expenses; but many local education authorities are willing to pay at least part of the cost; they realise how valuable to teachers is the opportunity to meet eminent scientists and to discuss their teaching problems with others similarly engaged.

Rich Undersea Mineral Deposits

The survey ship of the Royal Australian Navy, H.M.A.S. *Warrego*, has discovered extensive submarine deposits of rutile and zircon off Nambucca Heads (New South Wales). The new deposits discovered are spread over the ocean floor up to fifteen miles from the coast in depths ranging from one to three hundred fathoms. Several beach mining companies are investigating the possibility of dredging the minerals.

Exports of rutile, an ore which yields titanium, are expected to earn about £A7,000,000—£A2,000,000 more than last year. Total production should be twice last year's, topping the

Continued on p. 134

SCIENTISTS OF TODAY WANT THE INSTRUMENTS OF TOMORROW

Write for Pamphlet D. on
SINGER HIGH- AND LOW-POWER MICROMANIPULATORS

SINGER INSTRUMENT CO. LTD.
83 LONDON STREET, READING, BERKSHIRE, ENGLAND

University Correspondence College

Science Courses

U.C.C., with its staff of highly qualified Tutors, provides Courses of Study in Biology, Botany, Chemistry, Physics, Geography, Geology, Mathematics, Zoology. Full tuition is given for the General Certificate of Education (all Levels) London, Oxford, Cambridge, Northern, etc., London University Intermediate Science, and Final B.Sc. (General and Special), Engineering J.B. Prelim., Pharmaceutical Society Inter., and other exams. The College, founded 1887, is an Educational Trust. Moderate fees; instalments.

★ **PROSPECTUS** post free from the Registrar (48),
BURLINGTON HOUSE, CAMBRIDGE

The Golder MICROFLEX Eyepiece Camera

with reflex action by first-surface aluminised mirror, shutter operated by 9 in. cable release, and taking both plates and cut-film, 3½ in. × 2½ in. Suitable for all microscopes taking standard 23·3 mm. eyepieces.

Price £12 complete

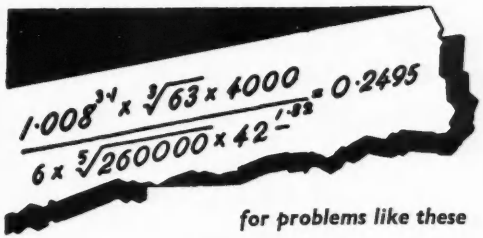
Leaflet M53 containing full information from

ALBERT GOLDER & CO.
137 DAIRSIE RD., ELTHAM, LONDON, S.E.9
Phone: ELTham 5126

WHAT TO DO ON THE NORFOLK BROADS

The complete guide to the Broads
Price 2*s.* 6*d.* (postage 7*d.*)

JARROLD & SONS LTD NORWICH



for problems like these

Pocket Size but as accurate as a 5 ft. 6 in. slide rule

The Otis King Calculator, with its 66-in. scales, is more useful than any ordinary slide-rule. Problems like the above—and of course others less complicated—are solved in a few seconds: accurate results to four or five significant figures can be read.

Yet the Otis King Calculator is handy enough and sturdy enough to be carried regularly in your pocket. Collapsed, it measures only 6 in. × 1¼ in. It is strongly made in metal with almost everlasting plastic coated scales.

And it costs only 57*s.* 6*d.* post free.

If you have any use for this amazing little instrument send the form below today. Unless you are completely satisfied your money will be refunded in full.

Carbic Ltd., 54 Dundonald Rd., London, S.W.19

The
OTIS KING
Pocket Calculator

Send this form today

To Carbic Ltd. (Dept. D), 54 Dundonald Rd., London, S.W.19.

Herewith cheque for 57*s.* 6*d.* Please send me one Otis King Calculator on your guarantee that if I return it within 7 days, you will refund the money in full.

Name.....
(BLOCK LETTERS, PLEASE)

Address.....

.....

.....

Classified Advertisements

OFFICIAL APPOINTMENTS

EXPERIMENTAL OFFICERS AND ASSISTANT EXPERIMENTAL OFFICERS in various Government Departments. The Civil Service Commissioners invite applications for pensionable posts.

The posts are divided between following main groups and subjects: (*a*) Mathematical and Physical Sciences, (*b*) Chemistry and Metallurgy, (*c*) Biological Sciences, (*d*) Engineering subjects, and (*e*) Miscellaneous (including e.g. Geology, Library, and Technical Information Services).

Age Limits: For Experimental Officers, at least 26 and under 31 on December 31, 1957; for Assistant Experimental Officers at least 18 and under 28 on December 31, 1957. Extension for regular service in H.M. Forces. Candidates aged 31 or over with specialised experience for Experimental Officer posts may be admitted.

Candidates must have at least one of a number of specified qualifications. Examples are Higher School Certificate, General Certificate of Education, Scottish Leaving Certificate, Scottish Universities Preliminary Examination, Northern Ireland Senior Certificate (all in appropriate subjects and at appropriate levels), Higher National Certificate, University degree. Candidates taking their examinations in 1957 may be admitted. Candidates without such qualifications may be admitted exceptionally on evidence of suitable experience. In general a higher standard of qualification will be looked for in the older candidates than in the younger ones.

Salary (London):

Experimental Officer. Minimum £925 (women £853); Men's scale maximum £1135.

Assistant Experimental Officer. Starting pay £365 (at 18) up to £655 (women £632) at 26; Men's scale maximum £805. Women's scales are being raised to reach equality with men's by 1961. Somewhat lower outside London. Promotion prospects.

Opportunities for further education.

Further particulars from Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting No. S94-95/57.

Interview Boards arranged at intervals, as required. Early application is advised.

ASSISTANTS (SCIENTIFIC). The Civil Service Commissioners invite applications for pensionable posts.

Age at least 17½ and under 26 years of age on January 1, 1957, with extension for regular service in H.M. Forces, but candidates over 26 with specialised experience may be admitted.

Candidates must produce evidence of having reached a prescribed standard of education, particularly in a science or mathematical subject. At least two years' experience in the duties of the class gained by service in a Government Department or other civilian scientific establishment or in technical branches of the Forces essential in one of the following groups of scientific subjects:

(*i*) Engineering and physical sciences.

(*ii*) Chemistry, bio-chemistry and metallurgy.

(*iii*) Biological Sciences.

(*iv*) General (including geology, meteorology, general work ranging over two or more groups (*i*) to (*iii*) and highly skilled work in laboratory crafts such as glass-blowing.

Starting-pay £340 (at 18) up to £460 (women £431) at 25. Men's scale maximum £635. Women's scale being raised to reach equality with men's by 1961. Somewhat less in provinces. Opportunities for promotion and for further education.

Further particulars from Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting No. S59/57.

Interview Boards sit at intervals, as required. Early application is advised.

APPLICATIONS are invited for pensionable posts as

EXAMINERS
in the
PATENT OFFICE

to undertake the official scientific, technical, and legal work in connexion with Patent applications.

Age at least 21 and under 35 years on January 1, 1957, with extension for regular Forces' service.

Candidates must have (or obtain in 1957) 1st or 2nd Class Honours in Physics, Organic or Inorganic Chemistry, Mechanical or Electrical Engineering or in Mathematics, or an equivalent qualification, or have achieved a professional qualification, e.g. A.M.I.C.E., A.M.I.Mech.E., A.M.I.E.E., A.R.I.C. For a limited number of vacancies candidates with 1st or 2nd Class Honours degrees in other subjects—scientific or otherwise—will be considered. Exceptionally candidates otherwise qualified by high professional attainments will be considered.

Starting pay for five-day week of 42 hours in London between £605 and £1120 (men) according to post-graduate (or equivalent) experience and National Service. Maximum of scale £1345. Women's pay above £605 slightly lower but is being raised to reach equality with men's in 1961. Good prospects of promotion to Senior Examiner rising to £2000 (under review) and reasonable expectation of further promotion to Principal Examiner.

Application form and further particulars from Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting S 128/57 and stating date of birth.

Interview Boards will sit at intervals, as required. Early application is advised.

MINISTRY OF LABOUR AND NATIONAL SERVICE. H.M. INSPECTORS OF FACTORIES (CLASS II). The Civil Service Commissioners invite applications from men and women for pensionable posts in the Factory Inspectorate which is being expanded. Age at least 21 and normally under 30 on June 1st in the year of application. Extension of the upper age limit for regular service in H.M. Forces and for candidates with exceptional qualifications. Starting salary £545 (at age 21) up to £710 at 26 or over. Scale maximum £980. Somewhat lower outside London. A special increment of £25, within the scale, is granted after satisfactory probation. Higher posts filled by promotion from Class II.

Duties include the enforcement of the provisions of the Factories Acts and Regulations affecting the safety, health and welfare of work-people and extend to all manufacturing industries and to certain other places, including Docks, Works of Engineering Construction and Building Operations.

Candidates should normally have a university degree (which may be in science or in arts subjects) or have technical qualifications of comparable standard (e.g. A.M.I.Mech.E.). Experience in works or other practical spheres is an advantage.

Candidates without degrees or similar technical qualifications will be considered if they have had extensive works or other practical industrial experience (especially in responsible positions) and if they have good general or technical qualifications.

Application may be made at any time, and so long as there are vacancies suitable candidates will be interviewed.

Particulars from Secretary, Civil Service Commission, 6 Burlington Gardens, London, W.1, quoting No. 280/15.

SPECIALIST ASSISTANT required by GOVERNMENT OF NORTHERN REGION NIGERIA Agricultural Department for one tour of 12–24 months in first instance either (*a*) with prospect of pensionable employment—salary scale (including inducement addition) £750 rising to £1554 a year, or (*b*) on temporary terms—salary scale (including inducement addition) £810 rising to £1716 a year plus gratuity at rate of £100–£150 a year. Commencing salary according to experience. Clothing allowance £45. Free passages for officer and wife. Assistance towards children's passages and grant up to £288 annually. Liberal leave on full salary. Candidates, preferably under 35, must be

highly trained in laboratory techniques of either Plant Pathology or Entomology and should possess Diploma of INSTITUTE OF SCIENCE TECHNOLOGY or similar qualification or experience. Write to the Crown Agents, 4 Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience, and quote M3A/35303/DI.

SLEEPING SICKNESS CONTROL OFFICER required by NORTHERN NIGERIA GOVERNMENT Medical Department for one tour 12–24 months in first instance. Salary scale (including inducement addition) £810 rising to £1386 a year. Gratuity at rate £100/£150 a year. Commencing salary according to experience. Clothing and touring equipment allowance £85. Free passages for officer and wife. Assistance towards children's passages and grant up to £288 annually. Liberal leave on full salary. Candidates, preferably single, should have good general education and agric. training or knowledge of surveying, mapping, entomology or botany. Write to the Crown Agents, 4 Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience and quote M3A/43728/DI.

APPOINTMENTS VACANT

THE
RESEARCH LABORATORIES
OF THE
GENERAL ELECTRIC
CO. LTD.,
NORTH WEMBLEY,
MIDDLESEX,

invite applications from PHYSICISTS, to work on Discharge Lamp Development, Crystal Analysis, and in Solid Physics.

ELECTRICAL ENGINEERS and PHYSICISTS are also required for work on Semiconductor Development, Transistor Applications, and Industrial Heating.

There are also vacancies for CHEMISTS and METALLURGISTS.

Successful candidates will have opportunities of advancement to positions carrying high remuneration.

An applicant should preferably hold a good honours degree, but men with pass degrees or higher national certificates will be eligible for some of these posts.

Apply, in writing, to the Staff Manager (Ref. RLO/120), giving particulars of experience, qualifications, and age.

LEO COMPUTERS LTD.

GRADUATES
IN
ELECTRICAL ENGINEERING
PHYSICS AND
MATHEMATICS
are offered training in
COMPUTER ENGINEERING

These will be senior appointments leading to full responsibility for the installation of LEO Computers in large organisations throughout the country. With the expansion of the Company, there are considerable opportunities for individual development awaiting men capable of contributing significantly to its work.

Training is aimed at giving a comprehensive understanding and practical experience of all aspects of the use of digital computers.

Candidates should hold an Honours degree, and be ready to reside for a time in different parts of the country.

Applicants should write, giving personal and educational details, and an outline of experience to:

The Personnel Officer,
LEO Computers Ltd.,
Elms House, Brook Green,
London, W.6.

CINEMA-TELEVISION LIMITED require male Chemical Laboratory Assistants for Vacuum-Tube Development work. Applicants should have completed National Service and be qualified to G.C.E. "A" in Chemistry and Maths or H.N.C. Chemistry. Facilities granted for further study. Five-day week. Pension Scheme. Canteen. 1 min. Bus and Rail services. Write, giving full particulars of age, experience and salary required to CINEMA-TELEVISION LIMITED, Worsley Bridge Road, Lower Sydenham, S.E.26.

THE OZALID RESEARCH LABORATORY at Loughton has vacancies for Assistant Chemists (male or female) for interesting research work on photoprint materials. Candidates should hold G.C.E. or preferably inter B.Sc. qualifications. Further scientific education is encouraged and assisted by the Company. Write Technical Administration (Ref. J.T.) Ozalid Co. Ltd., Lenthall Road, Loughton, Essex.

SECRETARIAL

ASSISTANCE offered to authors in preparing scientific papers; proof reading, editorial. Secretarial, committee and conference work undertaken. Box No. D.1536, Aldridge Press Ltd., 27 Chancery Lane, London, W.C.2.

SCHOLARSHIPS

THE NUFFIELD FOUNDATION

BIOLOGICAL SCHOLARSHIPS AND BURSARIES

THE NUFFIELD FOUNDATION, as part of its programme for the advancement of biological studies, is prepared to offer for the academic year 1957–8 a limited number of scholarships and bursaries to enable persons who have graduated in physics, chemistry, mathematics or engineering, but who have had no training in a biological subject, to receive such training in biology as will enable them, in due course, to undertake research and teaching in the United Kingdom in the biological sciences. THE SCHOLARSHIPS, which are senior awards, are intended for persons who have already undertaken some post-graduate research in their own subject. THE BURSARIES are intended to enable those who have recently graduated to complete a course of training in biological subjects, including, if considered necessary, a full honours degree course in biology. In the case of both scholars and bursars, the Foundation will pay the cost of university and/or college fees in addition to a maintenance award. Graduates of Universities in the United Kingdom, of either sex and preferably between the ages of 22 and 35, are eligible to apply.

Applications for awards in 1957 must be received before April 1, 1957, by the Director, The Nuffield Foundation, Nuffield Lodge, Regent's Park, London, N.W.1, from whom full particulars and application forms can be obtained.

L. FARRER-BROWN,
Director of the Nuffield
Foundation.

THE NUFFIELD FOUNDATION

SOCIOLOGICAL SCHOLARSHIPS AND BURSARIES

THE NUFFIELD FOUNDATION, in pursuance of its programme for the advancement of sociological studies, is prepared to offer for the academic year 1957–8 a small number of scholarships and bursaries to enable graduates in academic subjects other than the social sciences, psychology or economics, to study the social sciences. The Foundation's particular object is to enable men or women who are already well qualified in other disciplines, particularly the natural sciences or the humanities, to receive a training in, for example, political science, social psychology, anthropology, social statistics and sociology generally (but not economics) so that in due course they may undertake research or teaching in the United Kingdom in those subjects. THE SCHOLARSHIPS, which are the senior

awards, are intended for persons who have already undertaken some post-graduate work in their own subject. THE BURSARIES are intended to enable those who have recently graduated to take a course of training in sociological subjects. In the case of both scholars and bursars the Foundation will pay the cost of university and/or college fees in addition to a maintenance award. Graduates of Universities in the United Kingdom, of either sex and preferably between the ages of 22 and 35, are eligible to apply.

Applications for awards in 1957 must be received before May 1, 1957, by the Director, The Nuffield Foundation, Nuffield Lodge, Regent's Park, London, N.W.1, from whom full particulars and application forms can be obtained.

L. FARRER-BROWN,
Director of the Nuffield Foundation.

LECTURES AND COURSES

FARADAY HOUSE ELECTRICAL ENGINEERING COLLEGE

A THREE-YEAR COURSE, commencing each term, in Electrical Engineering to qualify for Associate of Faraday House and Graduate of the Institution of Electrical Engineers, followed by one year's practical training in Industry to qualify for the Diploma of Faraday House. For Prospectus apply to Department "E", Faraday House Electrical Engineering College, 66 Southampton Row, London, W.C.1.

TRAIN TO TEACH
SCIENCE SUBJECTS

EXCELLENT CAREER PROSPECTS

APPLICATIONS are invited for TRAINING as FULL-TIME TEACHERS OF SCIENCE in TECHNICAL COLLEGES and SCHOOLS. The next course of training will begin in SEPTEMBER 1957 and end in June 1958.

Applicants should normally

1. be between 25 and about 45 years of age,
2. have industrial experience,
3. possess one of the following:

   Higher School Certificate,
   Higher National Certificate,
   Professional qualification or degree.

MAINTENANCE GRANTS AVAILABLE
NO TUITION FEES

Write for full details and an application form to The Director (S/1/10), Huddersfield Training College, Queen Street South, Huddersfield, Yorks.

SOCIETIES

THE BRITISH INTERPLANETARY SOCIETY

12 Bessborough Gardens,
London, S.W.1

MEMBERSHIP and Fellowship is open to all interested in space-flight, rocket engineering and astronomy.

Full particulars of membership, together with a free copy of the Society's Journal and programme of lectures in London and many provincial towns, will be sent on request.

FAR AND NEAR—continued

100,000-ton mark. Main buyers will be America, Germany, France, Britain, and the Scandinavian countries.

Carver, a Negro Scientist

The most recent honour to the memory of George Washington Carver, the American Negro scientist, is the dedication of the Carver Science Hall at Simpson College, Indianola. Carver attended Simpson for three years. Born in the Southern State of Missouri during the American Civil War, Carver became an orphan at an early age. When he was ten, white friends, recognising his capabilities, urged him to seek further education.

By 1896 he had gained a Master of Science degree from Iowa State College, where he served on the Faculty as assistant botanist in the experiment station. Soon the leading U.S. Negro of those days, Booker T. Washington, president of Tuskegee Normal and Industrial Institute, invited Carver to join the Agricultural Department of the now-famous Negro school in the Southern State of Alabama.

It was as director of Tuskegee's Department of Agricultural Research that Carver began his distinguished career in agricultural science. He aimed to supplement the soil-depleting, one-crop system of cotton of Southern agriculture with two other crops, peanuts and sweet potatoes.

Columbus Rolling Globe

Available from Geographia Ltd., 68 Fleet Street, this globe is 4½ inches in diameter and costs 17*s.* 6*d.* It was invented by Robert Hardt, an engineer in Vienna, who has made an intensive study of globes. The Rolling Globe has the advantage that it can be looked at from all angles. It is completely separate from an annular base, which is calibrated in English miles, kilometres, and degrees of latitude. It is therefore easy to measure any distance on the great circle route of the earth. The globe is an attractive desk ornament in addition to being a useful object, particularly nowadays when aircraft are flying large distances across the earth.

Strontium Fall-Out Threat

A disagreement has developed among some of America's leading scientists over how much harm radioactive strontium may be doing to man's health.

The issue is one of degree of danger, since scientists do not dispute that strontium-90 is one of the dangerous by-products of atomic tests. (It has a half-life of twenty-five years, gets into food supplies through plants and animals, and is concentrated in human bone tissues, because of its similarity to calcium.)

Dr Willard F. Libby, of the Atomic Energy Commission, just reported new evidence indicating that man is not absorbing nearly as much Sr-90 as had been feared. Some of these findings, however, were challenged by the radiation hazards committee of the Federation of American Scientists, which suggested that Dr Libby has been "very optimistic" in his estimates.

Earlier this year, Dr Libby said that as much as 70% of the Sr-90 found in the topsoil which sustains life finds its way into human bones. Now he says the figure seems "much too high and possibly should be reduced to about 10%".

Ultrasonic Transducers

A new range of transducers for service in ultrasonic projects has just been announced by Technical Ceramics Ltd, of Towcester, Northants. Some of the applications already developed include the painless drilling of teeth, the performance of delicate brain-operations without recourse to the knife, and the drilling of square or irregularly shaped holes in almost any material. The crews of fishing vessels now measure sea depths with greater accuracy, and even detect the presence of small numbers of fish at very considerable depths with the aid of ultrasonic echo-sounders.

A "transducer" is a component which converts the physical vibration or ultrasonic wave into electrical energy and vice versa. In cleaning-equipment, for example, a transducer is used to transmit the ultrasonic radiation, while in measuring instruments the transducer has, in addition, to retranslate the returning ultrasonic wave into electrical energy so that instrument readings can be taken. The new piezoelectric transducers are made in ceramic, principally from barium titanate in a polycrystalline form, and are impervious to moisture and unaffected by temperature.

Errata

In the review of "The Conservation of Antiquities and Works of Art", by H. J. Plenderleith, DISCOVERY, February, p. 78, the words ". . . silicones and related materials" should have read: ". . . silicious and related materials". In the caption to the illustration, "miello" should have read: "niello".

Printed and Published in Great Britain by Jarrold & Sons Ltd, Norwich *Editorial Office: 244 High Holborn, W.C.1*

REKAB
INSTRUMENTS LTD

Do you wish to

BUY OR SELL

A modern microscope,
A pair of binoculars,
A telescope or camera?

Let us know your requirements. Best prices paid for good instruments

Repairs carried out: only the best workmanship. All repairs guaranteed

244 HIGH HOLBORN, LONDON, W.C.1 (HOLborn 1427)
(*A subsidiary of C. Baker of Holborn Ltd.*)

POSTAL TUITION
for London University
B.Sc.

The demand for Science graduates in industry and teaching offers great opportunities to ambitious young men and women. Why not study at home? Wolsey Hall (est. 1894) provides individually-conducted postal tuition for the London B.Sc. degree at reasonable fees. Tuition can also be arranged in some subjects for M.Sc.(Maths.). **Prospectus** from the Director of Studies, Dept. WM23,

WOLSEY HALL, OXFORD

Colourful Britain

A beautiful colour book of some of the most picturesque scenery in Britain

Price 8*s.* 6*d.*

JARROLD & SONS LTD. NORWICH

VACUUM TECHNOLOGY

"SPEEDIVAC"
TRADE MARK

CONTROL and 'PLUMBING' ACCESSORIES

The construction and maintenance of precision vacuum systems is now reduced to a simple, foolproof procedure by "SPEEDIVAC" accessories.

- **'SPEEDIVALVES'**
  High vacuum diaphragm valves—provide ABSOLUTE vacuum tightness.
- **DEMOUNTABLE VACUUM-PIPE UNIONS**
  Hand-tightened—for a permanently rigid and leak-proof connection.
- **GAS-CONTROL NEEDLE VALVES**
  Precision instrument-finished valves for the fine control of gas flows.
- **ROTARY VACUUM SEALS**
  For the control of rotary movements in vacuum systems.
- **MAGNETIC VALVES**
  FOR THE AUTOMATIC control of operational and protective devices.
- **CONTROL AND PROTECTION DEVICES**
  A complete range for the protection of H.T. and water-cooled plant.

. . . for Better Vacuum Service . . .

EDWARDS HIGH VACUUM LTD

MANOR ROYAL CRAWLEY · SUSSEX
CRAWLEY 1500 (10 lines) EDCOHIVAC, Crawley

VARIACS for S-M-O-O-T-H Voltage Control

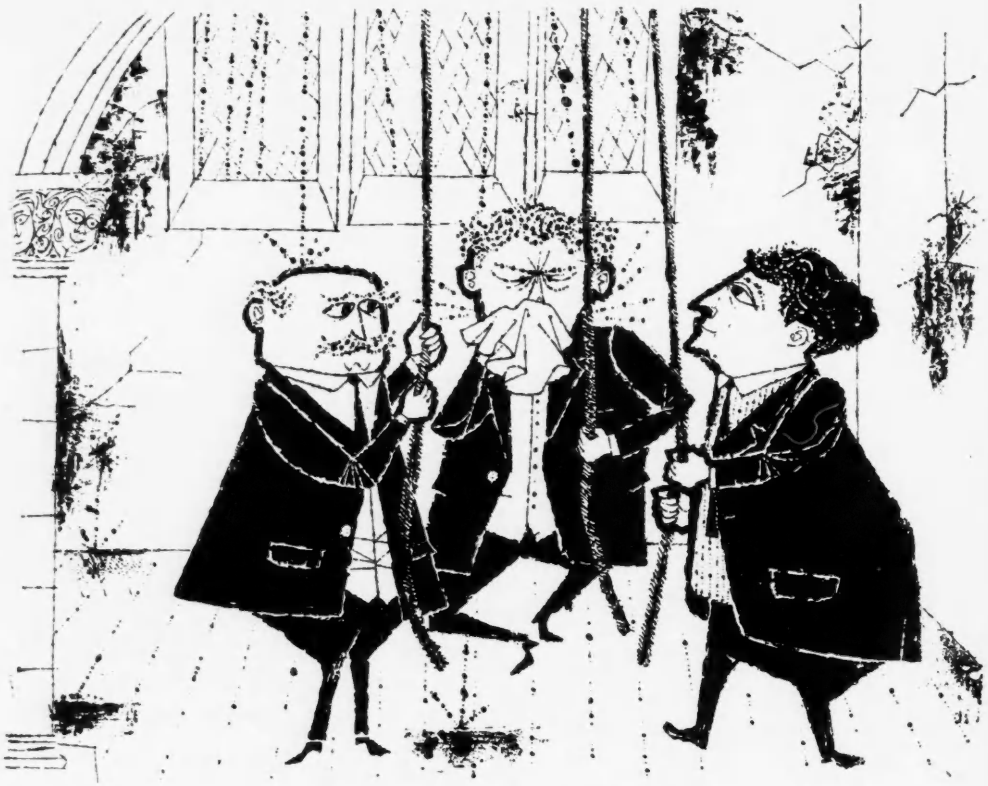
'VARIAC' is the *original*, continuously adjustable auto-transformer—and the only one having 'DURATRAK', a specially-treated track surface. For varying the a/c voltage applied to any electrical, electronic, radar or communications equipment a 'VARIAC' offers considerable advantages over any other type of a c control—it has longer life, absolute reliability, much increased overload capacity, resistance to accidental short-circuits and appreciably greater economy in maintenance. Voltages from zero to 17% above line are obtained by a 320° rotation of the shaft, which is equipped with an accurately calibrated direct-reading dial. Available in various sizes from 170 VA up to 25 kilowatts, including 3-gang assemblies for 3-phase working. 'VARIACS' are competitively priced, and, compared with the losses of resistive controls often save their initial cost within a year.

Write for a descriptive catalogue 424-U.K. and Price List VSP-57/16, which give full information about the entire 'VARIAC' range.

Claude Lyons Ltd.

76 Oldhall Street, Liverpool, 3, Lancs. Tel: Central 4641-2
Valley Works, Hoddesdon, Herts. Tel: Hoddesdon 3007-8-9

CL31



Ringing wet

It's not surprising that damp patches should now and then appear in old buildings. But when it gets to the stage that water is actually running down the inside wall — well, something has to be done. The congregation of a little church in the West Country were faced with just this problem. They consulted an architect.

" Silicones," he thought. So, on the outer wall, he brushed a water-repellent solution based on a silicone resin. And since then the wall's been perfectly dry. I.C.I. manufactures silicones for a whole host of purposes : water-repellents for masonry, textiles and leather; high-temperature electrical insulation; paint and polish ingredients; mould release agents; foam suppressors — and many other applications. Research is constantly going on; new uses are being developed. In almost every industry, I.C.I.'s silicones answer a need, solve a problem.

Thus, and in a thousand kindred ways, I.C.I.'s research and production are serving the Nation.

ICI